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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See Advertisement page 45, July 30. 3402

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See Full Page Advertisement, July 23.

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Intending Students should apply to the undersigned at an early date, for a form of application for admission to the College.
(Signed) Edwin Drew, Registrar.
July, 1920. J 95

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No pledge is given to accept the lowest or any tender.
R. R. Linthorne, Town Clerk.
3rd August, 1920. J 124

G. R.

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Note.—For particulars of other Government Property for Sale see *Surplus*, price 3d. at all bookstalls; or by quarterly subscription of 2s. post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. H 966

PUBLIC WORKS MINISTRY.

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Tenders will be Received at the office of the Inspector General of Irrigation, Upper Egypt — Public Ministry—Cairo—until Noon on the 18th September, 1920, for the PURCHASE of a MOTOR LAUNCH for the 4th Circle of Irrigation.

Persons wishing to Tender can see the specification and obtain all other information on any day, official holidays excepted, from Nine a.m. to One p.m. at the office of THE INSPECTOR GENERAL OF IRRIGATION for Upper Egypt, Cairo, and also at the office of Sir Arthur Webb, Queen Anne's Chambers, Westminster, S.W. 1. J 182

APPOINTMENTS OPEN.

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Applications are Invited for the JUNIOR ASSISTANT-SHIP in the Department of Civil Engineering. Salary £200 per annum.

Particulars may be obtained from Professor HUMMEL, to whom applications should be sent not later than August 21st, 1920. J 70

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LECTURER IN ENGINEERING.

Applications are Invited for the above POST at a salary of £350 to £400 per annum according to qualifications.

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Required, in September next, the Full-time Services of a LECTURER in METALLURGY.

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Stipend £300 per annum.
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Further particulars may be obtained from
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J 109

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Salary £400.
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By Order,
L. Hewlett,
Town Clerk and Clerk to the Local Education Authority.
Town Hall, 27th July, 1920. J 36

THE TECHNICAL COLLEGE, LOUGHBOROUGH.

H. Schofield, M.B.E., B.Sc. (Lond.), A.R.C.Sc. (Lond.), A.M.I.C.E., D.I.C., Principal.

Wanted, for the Commencement of the Autumn Term, a LECTURER in MATHEMATICS for the Senior College.

Applicants should be graduates of a British University, and previous teaching experience is desirable.
Commencing salary £300 per annum, with suitable increments upon satisfactory service.
Applications must be submitted to the PRINCIPAL of the College on the prescribed form, which may be obtained from him.
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Forms of application with further particulars can be obtained on application to the SECRETARY (T.2.b.), AIR MINISTRY, Kingsway, W.C. 2. H 998

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Applications are Invited for POSITION of an ASSISTANT to the ADMINISTRATOR of Housing Development Schemes. The appointment will be a temporary one. The person selected will be required to act as the principal assistant to the Administrator in the control and supervision of the large contracts for housing development schemes entered into by the Council. Candidates should be about forty years of age, must have been trained either as civil engineer, or architects, and have had considerable experience in the conduct of large construction works. Experience as a resident engineer or as an architect with outdoor experience on large construction work is required, and commercial knowledge gained, on the staff of a large contractor would be a qualification. Preference will be given to candidates who have served, or attempted to serve, with His Majesty's Forces. Applications must be made upon a form to be obtained from the Administrator of Housing Development Schemes, County Hall, Spring Gardens, S.W. 1. Stamped Addressed foolscap envelope necessary. Candidates will be required to state on the application form the salary desired. All communications to be marked "Assistant to Administrator," and application forms must be received at the County Hall not later than 11 a.m. on Friday, 20th August, 1920.

James Bird,
Clerk of the London County Council.
J 75

Works Manager Wanted for large Engineering Works in West of Scotland. Young energetic man with up-to-date experience.—Write, stating full particulars with salary required to "Ferro," Box 431, Sells Advertising Offices, Fleet Street, E.C. 4. J 115

Foundry Manager Wanted for a modern Foundry in the Manchester District engaged on high-class Machine Tool-work. Must have had a combined practical and theoretical training. One who can manage men wisely and instil into them the desire of producing efficient work cheaply. The position is a permanent one and offers a good opportunity to a first-class man. State experience, age and salary, J 81, Offices of Engineering.

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Permanent Way Inspectors.— WANTED, for Railway in the Argentine, TWO Thoroughly Experienced MEN, well up in railway maintenance. Must be between 30 and 40 years of age. Salary £480.—Write, giving references and details experience, INSPECTOR, c/o Streets, 30, Cornhill, London, E.C. 3. J 94

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Attractive salary to suitable candidate.—Address, in the first instance, by letter, giving details of age, experience, qualifications and salary desired, J 105, Offices of Engineering.

Required by Contractors, CAPABLE ASSISTANT ENGINEER, with a practical knowledge of reinforced concrete design and execution. Knowledge of steel work and general building construction an advantage.—Address, stating age, experience and salary required, with copies of testimonials, J 118, Offices of Engineering.

Business-getting Engineer WANTED by Scotch Firm of Contractors. Must have talent for and some experience of the work. Good education, address, and sound engineering training essential. Required to travel in United Kingdom, and take charge of whole business getting organisation, advertising, &c. Retaining fee expenses, and commission on results. Whole time appointment. Exceptional opportunity for able and energetic man.—Address, J 150, Offices of Engineering.

Executive Engineers, GRADE III., PUBLIC WORKS DEPARTMENT, REQUIRED by the GOVERNMENT of the GOLD COAST for two tours each of twelve months' service, with possible permanency.
Salary (a) Senior men with special experience £600—30—£720—40—£920 a year; (b) Junior men £480—30—£720 a year.
Free single quarters and first class passages. Liberal leave in England on full salary.
Candidates over 32 years of age, who have had practical and general experience as Civil Engineers on roads, Buildings, and other Public Works, should apply at once in writing, giving age and brief details of experience to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, London, S.W. 1, quoting M/9606.
Candidates must have served in some branch of His Majesty's Forces during the late war unless satisfactory reasons for not having done so can be furnished. J 126

Civil Engineers Required for the GOVERNMENT RAILWAYS in TANGANYIKA TERRITORY (formerly German East Africa), for one tour of 20 to 30 months' service with possible permanency. Salary £400 per annum rising by annual increments of £30 to £500 per annum and thereafter by £25 per annum to £600 per annum. An outfit allowance of £30 is payable on first appointment. Quarters free of rent and first-class passages provided. Liberal leave in England on full salary. Candidates age 25 to 30, preferably single, who have good experience on Railway construction and Maintenance, should apply at once in writing to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, giving age and brief details of experience, and quoting M/Tang. 10087. Applicants must have served in some branch of H.M. Forces during the late war unless satisfactory reasons for not having done so can be furnished. J 148

LIGHT STEEL CASTINGS.

By R. J. Dunderdale.

Prior to the war, the chief source of the light steel castings bought for use in the motor and allied trades in this country was the Continent, and the chief countries from which they were obtained were Switzerland, Belgium and Germany. This condition of affairs was largely brought about by the restrictions on the early use of motor cars in this country, and after that, the business in light steel castings having begun abroad in a small way was further fostered by suitable local conditions, such as cheap electric power, and special skill and knowledge built up by the early makers during the period when competition from this country was unknown. In this country at that time steel casting was much developed, but on the whole for much heavier classes of work, and the large dimensions of the average casting rendered absolute faultlessness far less necessary than in light castings designed to give strength for weight in the motor trade where superfluous weight is in itself a definite drawback. At first on the Continent, and later in this country, the chief source of the really light steel casting was the crucible. This method of melting was excellent as far as control of mixture and temperature went, but for obvious reasons was exceedingly expensive in labour, in crucibles, and in fuel, and when the light steel castings industry in any one factory once began to exceed the dimensions of 10 tons or 12 tons a week, other methods of production were sought. The first of these to come into prominence was the small converter, and the most popular of these were the Stock and the Tropenas types. With suitable pig-iron and skilled supervision, these proved fairly successful, but in the early days to ensure that the metal was properly killed before being poured a good deal of aluminium and other objectionable ingredients were used. The introduction by Heroult and others of a suitable electric furnace clearly pointed the way to the most controllable and economic method of making the steel for this class of casting where it was wanted in any quantity, and it was this which largely tended to make the industry so successful in Switzerland and South Germany, and some parts of France owing to the supply of cheap electric current, generated by water power.

The war, however, caused a complete change in the growth of the light steel casting industry in this country. Shortly prior to the war, Messrs. Lake and Elliott, of Braintree, had bought and installed, and were successfully running, a small Heroult furnace. This was the first electric steel furnace in this country, and in spite of the fact that electric current generated locally could not be obtained very cheaply the product was successful. When the war had been proceeding some time, the necessity for enormous quantities of medium and light steel castings previously usually made in this country as forgings became apparent, and a considerable number of electric furnaces for the purpose of making road wheels, tank links and similar transport material were installed. At the same time the small converter type of plant was also considerably enlarged, and the country now finds itself, except as regards really cheap sources of electric current, quite well placed to compete in its own and the world's markets in this class of casting. In fact, there are at present, in this country, about 15 foundries of varying size making successful light steel castings.

Putting aside crucibles and converters which are not so successful as the electric furnace in the hands of a really skilful steel maker, the types of furnace chiefly in use in this country are the Schneider, Heroult, and "Electro-Metals" furnaces, in sizes varying from those capable of taking ½ ton, to those capable of taking 12 tons to 15 tons at a charge. Probably the most suitable size for general work in castings ranging from 14 lb. to 140 lb. weight is the 2-ton furnace, but even in this small range it is desirable to have the furnaces graduated in size and used near the type of casting which they would be chiefly employed on, and the best plan is for the very hot metal required for the smallest and thinnest types of castings to be shanked direct from the smaller furnaces to a floor of moulds laid out close to them, while the larger work, which can be conveniently poured at a lower temperature from a 2-ton to 5-ton ladle, is laid out in a large bay with a plentiful supply of cranes and also containing the larger furnaces. As some guide to the rate of production, which may be expected, an efficiently run 2-ton unit should provide 60 tons to 70 tons of steel in ladle in a week of 140 hours, working continuously on either the two or three-shift principle. This, of course, does not apply to a single furnace by itself, but to one of a set of units containing at least one stand-by.

The sand required for this type of moulding differs completely from that used for iron foundry work, and considerably, both in character and treatment from that used for heavy steel castings. Its physical condition should be hard, sharp and not easily friable. Chemically, it should contain 97 per cent. to 98 per cent. of silica, and as little matter of other kinds as possible, though a small quantity of iron is not objectionable. In regard to size, it is probably as well that the sand itself should not pass through an 80-mesh, as its texture will be rendered decidedly finer than this by the clay used for bonding. The best clays for this purpose contain about 30 per cent. of alumina, as little organic matter as possible, and, according to Professor Boswell, a certain amount of iron is an advantage. The sand and the clay to be used should be very thoroughly mixed and milled and the moisture of the resulting mixture can be as much below 4 per cent. as will allow the sand to take a good impression of the pattern and not crumble or fall out when being dressed or turned over.

Most of the foundries at present producing this class of castings in this country suffer from their work being too much of a jobbing nature, and from having to cater for too many classes of customer with very varying ideas as to the designs of the castings they require; but this matter will be further discussed at the end of the present article. Taking foundries as they are now, a good iron moulder will usually make a good steel moulder with a little training, and small quantities and intricate patterns are always best handled by this class of labour, or its apprentices, where the work is simple.

For all types of light castings where large numbers per week are required and where the designer has paid reasonable attention to the necessities of moulding, machine moulding is better both as regards the quantity and quality of the work; for the pattern, if once correctly made and carefully used on a machine will last far longer both as regards its total life and the condition and accuracy of its surface than a pattern which has been rapped and pulled in and out of the moulds by hand. In this connection, patterns even for floor moulding are better made of metal wherever there is sufficient quantity of castings required to justify this course, for in the event of the moulding sand becoming too close and supplies of sharp sand not being available owing to railway congestion or other misfortune, thorough and conscientious venting, though good for the mould and the casting to be made, is a sure method of damaging the surface and letting moisture into a wooden pattern.

Prior to the war, moulds for all classes of work in steel were nearly always made in green sand, and then baked, being painted with tar from time to time in the process. There is no merit in this procedure in itself, and for 90 per cent. of the light steel castings now made, it has been found that a green mould does all that is required. The method, however, still retains its merits for very thin work and cored pressure work, provided the mould is made suitably weak, and well vented. Its adoption arose probably from the fact that, owing to the high temperature at which most and especially very light steel castings are poured, the generation of gases from moisture and organic matter near the surface of the casting was so rapid, that, even with a pretty free and open sand, these gases could not get away with sufficient rapidity to prevent blowholes and sponginess in the metal, and in the early stages of the trade this sponginess was often wrongly attributed to the condition of the steel and not to the condition of the sand. Blowholes, as opposed to drawholes, and short-running or sponginess, due to the condition of the sand are very frequent causes of unsatisfactory castings, and in this connection it may be mentioned that the practice of piling, now fairly common with light iron castings and snap-flask work generally, is probably not so successful as might be expected, owing to the steam generated in the lower moulds getting into the upper moulds before the steel does, and preventing the exit of the gases properly belonging to the moisture or organic matter present in those moulds. This same trouble is apt to occur when two patterns (parts, for examples, of a set) are separately cast in the same box. It is much better in cases of this kind to endeavour to cast all the parts in the box as nearly as possible simultaneously from a suitably situated runner.

Core-making has now become almost the most important part of moulding in a light steel castings foundry doing a reasonable amount of repetition work, as so many castings, even when reasonably designed, require a certain number of external as well as internal cores, and this point can easily be brought home to users of this type of casting by mentioning that the average back axle casing, a fairly simple looking casting when complete, takes from 10 to 18 cores in its make-up, the number required usually being near the higher figure. The amount of labour and skill required in a case like this at once becomes apparent when it is remembered that only a comparatively few minutes are required to make the cope and drag complete on a moulding machine, and, of course, if the machine is not to stand idle, all these cores have to be made in approximately the same time. With regard to the quality of sand used in core-making, one similar to, but rather finer than the facing sand for the moulds is desirable, and a great many more cores have to be baked than moulds, in order that the core may be made of thin section and well vented or filled with ashes, so that when the casting contracts it is not torn asunder on a solid resisting internal body. For this class of work, metal core-boxes are, wherever possible, desirable, just as are metal patterns, and in any case cores should be made in boxes, and strickled or formed otherwise as little as possible.

Pouring the steel should, as a rule, be done as slowly as is consistent with filling the mould without any cold shuts, and moulds should be cast as far as possible with those surfaces which are going to be machined downwards, as in iron practice. This, of course, is impossible in a great many light steel castings, for many of them are machined almost everywhere, and in this case the only remedy is an elaborate system of chilling, including chills left in the body of the casting, where a heavy section of the metal by its slower cooling would tend to be pulled asunder or used as a feeder by more rapidly cooling portions around it.

The design of light steel castings in this country is only now beginning to receive the attention which from the first was its necessary due, and even to this day quite a number of drawings and patterns for light steel castings are produced, from which a sound casting in all cases cannot reasonably be expected. In this connection the most hopeless fault is found when a thick section is merged into from all sides by thinner sections. In this case, the troubles mentioned above when dealing with casting are inevitable.

Failures in light steel castings arise from a multitude of causes, but the chief among them are: (1) *Short-run Castings*, which are due either to using too cold a metal for thin sections or to insufficient venting producing a gas-lock in some portion of the mould, the gas simply preventing the metal from flowing into that portion.

(2) *Slag.*—In the case of light steel castings poured from the bottom of a 2-ton or 3-ton ladle with a good thick protecting slag on the top of the metal, a certain number of castings which prove to be partly slag are inevitable, and the usual practice in this case is to see that when the bottom of the ladle is being approached, the metal is only run into unimportant castings. There is no danger of the customer receiving castings with this fault, as the very severe fettling required by the steel casting effectually ensures a defect of this nature making itself evident.

(3) *Blown and Spongy Castings* are caused by

rising metal, a moist and badly vented mould, the presence of small pebbles (which split against the surface of the casting), and dampness adhering to external chills. In the early days of the trade, a good deal of spongy work was always attributed to rising metal, where it should more correctly have been attributed to the condition of the mould. Analysis and micro-structure will always show which of the principal causes it is, but as a good rough guide it may be taken that rising metal gives a casting which is spongy all over, whereas bad venting and moist sand, &c., usually give castings which are only spongy in places, and those places where an experienced moulder would be led to expect it.

Repetition work is now done almost entirely by machine, and for steel castings there is no doubt that the jolt-ramming type of machine is the type required. In a steel casting it is essential that the face should be hard and the backing moderately weak, in order that the high temperature of the metal and its weight shall not break up the face in the first place, and the slower cooling portions shall not be torn apart by a mould which is uniformly too tightly rammed. There are now several good makes of jolt-ramming machines, chiefly air-driven, but probably the best machines of this type are mechanically driven, either by electrical gear or cams. Core-making machinery is likely to play a considerable part in the development of the industry. The plant in a light steel casting foundry most essential to larger output, and least considered, is the crane and transport system. It is not too much to say that everything in a foundry can work faster than this system, however efficient it is; and therefore, provided one crane or transporter does not foul another, there cannot be too many of them.

With regard to fettling, this is a totally different proposition from the fettling of iron, brass or gun-metal castings. Sand-blasting has to be done with steel shot and nozzles. The usual tumbling boxes have not been found sufficient with the hard burning on which takes place all over a steel casting, and especially in the angles and curves of intricate specimens.

Cutting off runners and risers after sand-blasting is most cheaply done with a saw or chisel, but owing to the fact that the average light casting is quite asymmetrical, it is almost impossible to set up castings in quantity to be dealt with quickly in this way, and therefore the oxyhydrogen or oxy-acetylene flame is the most popular method. The castings after that can usually be trimmed to a fair finish with a pneumatic chisel and a grindstone. Small defects are then ready to be welded, and the castings should afterwards be well soaked at a temperature of about 900 deg. In this connection it should be pointed out that a steel casting of about 0·2 per cent. carbon, low silicon and manganese, properly soaked, will give tests equal to the best forged or wrought mild steel, and be in every way just as reliable, but if this heat treatment has not been employed light mild steel castings might, as a rule, just as profitably have been made from malleable cast-iron, and with the latter material the finish would always have a nicer appearance.

Little need be said about organisation, for though it is the line along which most progress will have to be made, it usually will take its general form from procedure in the establishment to which the foundry belongs. Generally speaking, a light steel castings foundry of any size would very profitably employ an experimental department to determine the best way of making moulds before putting a repetition job into bulk production. In this connection there are several dangers, however. Such a department should avoid a method which cannot be practically employed with machine moulding, and of two methods should choose one which is most suitable to the boxes and tackle existing in the foundry, and if the tackle is not adapted to the best method of casting, this fact should be put on record.

The experimental department also should not be used as a rate-fixing department. This is a most fatal error. Its chief function being to find the best way of doing a job; the rates should be fixed afterwards, keeping in view that the job has to be done according to the method described.

Piece work is applicable to every job done in a foundry or fettling shop, and for the ultimate good of both the skilled and unskilled men in the trade, they should be induced to adopt it at whatever expenditure of tact and energy, for while the industry is exceedingly well placed for the next year or so, a well-organised and properly rated industry alone will survive the severe competition to be expected from Belgium, France, Switzerland and Germany when the rate of exchange and other factors not regulated by the nature of the industry itself have settled down. At present the rate of exchange is inclined to work in our favour, both as regards Switzerland, where the sovereign is depreciated, for their selling price is apt to be too high; and the other countries mentioned, where the sovereign is enormously appreciated, owing to their difficulty in getting raw material, but this state of affairs will not last indefinitely.

As has just been remarked, the future of the industry should be good for some years to come in any event, but when competition begins to arise the armour of the industry will, if unchanged from the present, show several weak spots. Probably the best way to establish this young industry while it is now in a healthy infancy would be for the light steel castings users to combine with the present manufacturers and arrange to parcel out the work to those manufacturers in such a way that one firm is only engaged on two or three standard types of job, this being with regard to the repetition work. With regard to the jobbing work, any small quantities of this type should be reserved entirely for two or three foundries suitably equipped with a proper range of furnaces and the bulk of the skilled steel moulding labour, so that the two types of work are not mixed, and the various factories are in consequence not saddled with the extremely complicated and expensive work-allotting and costing systems which would now be necessary to disentangle the costs of those foundries where more than 50 or 60 types of pattern are coming into and going out of work weekly.

Until something in the nature indicated is done, the next best step is for the buyers and users of light steel castings in this country to support the home producers, even in the face of a little financial disadvantage, in order to enable this very essential industry to secure the place in this country it was unable to take prior to the war.

CAVITY WELLS IN INDIA.

In continuation of the article on Percolation Wells in India, published in our last issue (*vide* page 153 *ante*) it is proposed now to deal with what are known as "Mota" or "Cavity" wells. In alluvial soil where a stratum of a sufficient depth of clay overlies water-bearing sand, a "Mota" or "Cavity" well can be installed. The masonry cylinder forming the well steining should be impermeable and sunk into the clay to a sufficient depth to make a watertight joint. If the cylinder has passed through water-bearing sand above the clay, all leaks under the well centre must be carefully stopped up so as to prevent any inflow of sand into the well. The inside diameter of the cylinder should be of sufficient size to receive the pumping or baling apparatus and to contain the sand brought up by the pipe or borehole to be described later. When the masonry cylinder has been well bedded into the clay, and the curb made as watertight as possible, a borehole, or pipe, is driven through the clay to the underlying sand; as soon as the pipe is clear of the clay, and reaches the water-bearing sand, the head of water drives water mixed with sand up the borehole into the well. Sometimes there is such a rush of water that the men working in the well get drenched before they can escape. The sand is cleared out of the well and the water pumped or baled out of the well, when the water rushing in from the water-bearing sand below, again fills the well with sand and water. This operation is repeated until the in-rushing water ceases to bring sand along with it; when the well is ready for use.

The removal of the sand from the water-bearing stratum below the clay must cause a cavity under the clay bed, and just below the borehole; therefore, so long as the velocity of the water flowing through the sand into the cavity is at any point of the sand surface of the cavity greater than the velocity of the critical discharge per square foot area of the sand, the cavity must continue to enlarge and the sand displaced will be carried up into the well. The function of the cavity is therefore to provide for the discharge of the water an area of sand sufficiently large to reduce the velocity to a point at which the critical discharge per square foot area of the sand is not exceeded. Fig. 1 explains matters. The pipe, at its lower extremity, should not project into, but should be flush with the clay; and at its upper extremity should not project more than 2 ft. into the well. The depth of the cavity will be greatest at the centre, gradually diminishing to nothing where the sand meets the clay roof. The maximum depth

Fig. 1.

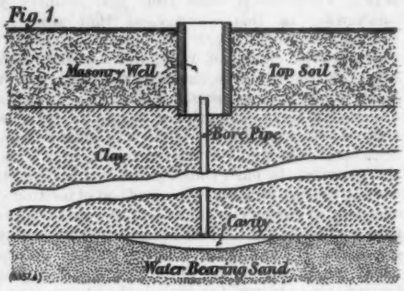
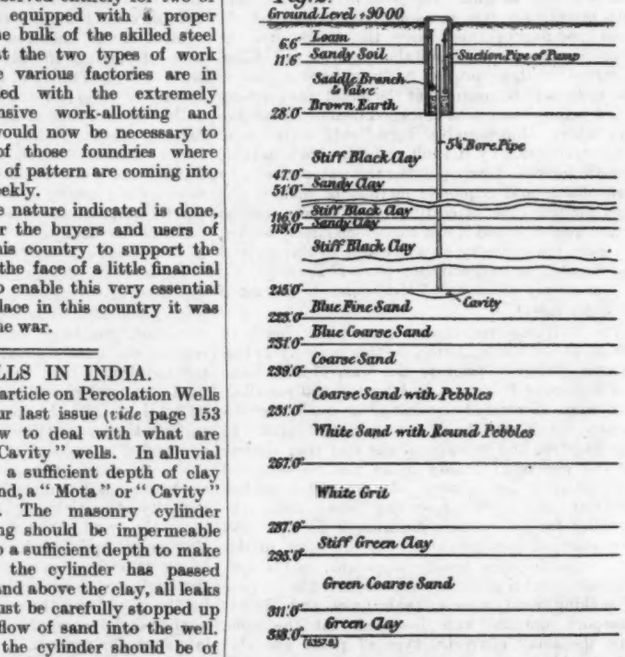


Fig. 2.



for a cavity of large size will be scarcely 1 ft., the average being about 3 in. It will be thus seen that given the conditions for constructing a "Cavity" or "Mota" well, a greater quantity of water can be obtained from it than from a percolation well of the same diameter. The supply is also independent of the diameter of the well. A diameter of 7 ft. is required for manipulating the *Mote*, or leather baling bucket, and assume that a cavity has been formed by the removal of 230 cub. ft. of sand. Taking the average depth of the cavity as 3 in., the diameter of the cavity, if circular, would be about 34 ft., or the "Mota" well of 7 ft. diameter would be equal to a percolation well of 34 ft. diameter.

The conditions necessary for a "Cavity" or "Mota" well are, that there must be a layer of clay or other firm impervious substance of sufficient strength to bear the weight of the masonry cylinder and roof in the cavity in the sand below. The layer of clay must not be of such great thickness as to make the cost of boring prohibitive for ordinary irrigation wells. The layer of water-bearing sand must be at a sufficient depth below normal ground

water-level to obtain the head of water sufficient to force the sand and water into the well. For ordinary depths the head required is :—

(i) Ten feet to obtain velocity in the tube to move the sand and give the required discharge.

(ii) Five feet depth in the well for the leather bucket or baling apparatus to work in.

(iii) Three feet for fluctuations in the ground water-level.

That is, the normal depth of water in the masonry well should be about 18 ft. The pipe should be of such a diameter as to reduce friction to an economical limit, and the projection of the pipe into the well should not be so high as to reduce the head requisite to give the water the necessary velocity sufficient to move the sand and form the cavity. If a cavity well begins to yield a diminished supply, it is due to either the general fall of the ground water-level in the locality, or the choking up of the bottom of the well and borehole. The rubbish should be cleared out, and if sand is found at the bottom of the well, there is possibly a leak between the well curb and the clay foundation, or a crack or hole in the masonry cylinder which allows sand from the layers above the clay to percolate into the well. This can be remedied by plugging the curb or repairing the cylinder. The sand may also be due to the subsidence of the clay foundation, when the defect becomes serious, and requires skill and ingenuity in overcoming the difficulty.

Fig. 3.

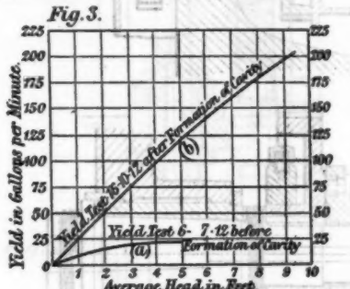
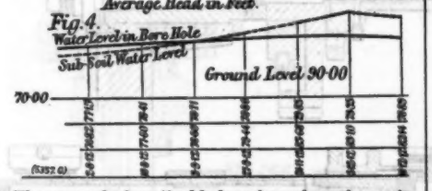

Yield in Gallons per Minute.
Yield Test 6-7-12 after Formation of Cavity
(b)
Yield Test 6-7-12 before Formation of Cavity
(a)
Average Head in Feet.

Fig. 4.



The example described below shows how the cavity principle was applied in the case of a deep borehole in order to obtain a supply of potable water for a small town in India ; the surface and subsoil water being contaminated. The locality was the flat alluvial delta of the Cauvery River. A borehole, 5½ inches internal diameter, was sunk through the alluvial clay to the sandy strata below, *vide* geological section of the boreing, Fig. 2. The pipe was first taken down to a depth of 318 ft. below ground level, and attempts were made to pump water from the various strata of sand found below the clay, but without success, the pipe invariably becoming choked with sand. It was then suggested that the cavity principle be tried ; the pipe was accordingly raised to be flush with the bottom of the stiff black clay, at 215 ft. below ground level ; a masonry well, 6 ft. in diameter, was sunk round the borehole to a depth of 28 ft., and lined on the inside with a steel cylinder to exclude the subsoil water ; and a watertight joint was made between the borehole pipe and the inside of the well by a plug of concrete. In order to facilitate the clearing out of the well a saddle branch, 4 in. in diameter, fitted with a valve, was fixed to the borepipe 2 ft. 6 in. above the concrete plug (see Fig. 2). The cavity was formed by first closing the valve on the saddle branch, and pumping the well dry. The valve was then opened and water and sand rushed into the well. The valve was then closed, the water pumped out of the well, and the sand cleaned out. The operation was repeated until 68½ cub. ft. of sand had been removed from below the clay stratum. The curve (*a*), Fig. 3, shows a yield test made on July 6, 1912, before the sand was removed ; and curve (*b*), Fig. 3, shows a yield test made on October 16, 1912, after 68½ cub. ft. of sand had been removed. Fig. 4 shows variations in water-level in the borehole, and in the subsoil water-level of the locality. The success of this experiment has led to another bore being put down in the locality some 1,700 ft. from the well above described. The bore pipe in the new well is 12 in. internal diameter, and in order to obtain a head sufficient for scouring purposes, the catch well is being made 40 ft. deep.

RECENT MACHINE TOOL DEVELOPMENTS.—No. XIV.

By Joseph Horner.

Drilling Machine Spindles.—These have been subject to changes consequent on the increased speeds which have become necessary, and also by reason of the greater severity of the axial thrusts imposed. These facts have occasioned the substitution of ball races for both radial and endlong pressures. At the same time methods of driving have been much improved, and better support has been afforded to the journals. The feature which characterises the spindles of present-day machines in strongest contrast with that of the designs, which, without being very old, are hardly recent, is the great increase in speeds. These, in some of the lighter machines approach those of grinding spindles. While there has been a general speeding-up of all machines consequent on the use of drills of the high-speed steels, the greatest advances are associated with the sensitive designs. Here the speeds for the smallest drills may be as high as 10,000 r.p.m., and the feeds correspondingly rapid. The abandonment of a geared drive, for that of a belt, has been a necessary result, accompanied with different methods of accomplishing speed changes. The desirability of drilling a number of small holes simultaneously has led to the numerous multiple-spindle designs, all belt, or gear driven from a common shaft, and having centres fixed, or adjustable. While in most cases the spindle is fed downwards, in some the table is fed to the spindle. These machines occur in countless variations, mostly being designed for general purposes, but now in increasing numbers for strictly specialised manufactures. The gross output of these machines can be seriously lessened if but slightly uneconomical features are incorporated, the non-efficiency due to which may be only counted in seconds per operation.

Fig. 280.

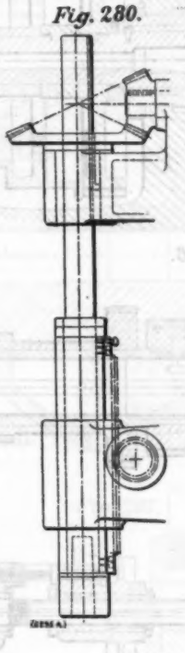


Fig. 282.

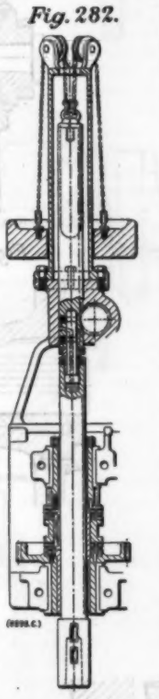
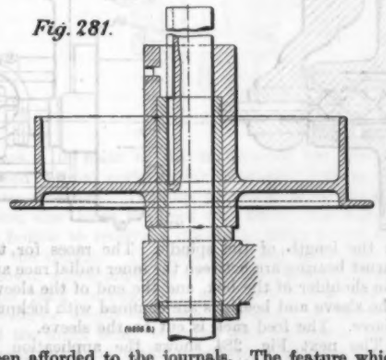


Fig. 281.



The early spindles, suitable enough for the speeds then in use, suffered from two defects, the plain bearings for the journal necks, with much resulting friction, and the plain thrust washers located below, or at the head of the spindle. To provide for the feed the spindle is key-grooved through a portion of its length, enough to afford its maximum amount of descent, and the driving element makes a sliding fit over and in it, so that the spindle while being rotated can be fed. The driving was, and still is, in heavy machines through either bevel, or spur gears. Even when duties were light, gears were retained, and these, in consequence of their friction and noise, set a limit to high speeds. A long step in advance was the substitution of the belt drive to a pulley encircling the head of the spindle, to which the belt is brought, and returned over jockey pulleys. Later, the pull was taken off the spindle, and transferred to an encircling bush or sleeve. The feed, instead of being through a screw cut on the spindle and ratchet gear was transferred to a pinion and rack cut on the outside of a lower sleeve, through which the spindle passed. With various improvements, this general design is retained on many machines, the principal changes being those that concern the bearings.

Ball Races.—The fact which now dominates every other in spindle design, in the sense that it is now being nearly universally applied, is the substitution of ball races for plain, smooth bearings. The friction is perhaps one-fourth that of plain bearings, a fact that is favourable to the highest speeds. In many of the earlier spindles, radial pressures and end thrusts were frequently combined as in the bicycle type with diagonal lines of pressure, as is done in many grinder spindles. Almost invariably now separate races are used for the two kinds of pressures, and the balls also are confined in cages instead of running loosely in contact. Generally the radial pressures are taken in the pulley, and the ball thrust below, close to the termination of the spindle. In some, however, two ball thrusts are fitted, one at the bottom, and the other about midway between this and the pulley. But, for sensitive spindles there does not seem to be much necessity to make the separation, since a very moderate thrust load can be taken by a radial bearing, sufficient for small drills. This is more especially correct of the Skefko design, than of the ordinary types.

Examples of Drilling Spindles.—Fig. 280 is an illustration of the spindle of a drilling machine of the bevel gear-driven design. Speeds are changed by spur gears on horizontal shafts (not shown) in conjunction with a four-stepped belt-driving cone. Feeds are through three-stepped belt cones, and worm gear. The spindle is driven by the bevel wheel directly through one key groove, into which a long key, occupying the bore of the gear, fits, the key being anchored in the bore. Only one groove is cut—in high-speed spindles there are two for counterbalance. The lower portion of the spindle rotates in a long sleeve, of cast-iron, that goes through the arm. To this a rack is screwed, for the operation of the feed from the pinion, and for making height adjustments. Thrust is taken by a single washer between the shoulder of the drill socket and the lower end of the sleeve. Locknuts above the sleeve compensate for wear. The design seems rather crude now, but the form was long in evidence, and many such machines must be in use to-day.

Fig. 281 is an example of the method now usual

of driving a spindle with a pulley which does not encircle the spindle directly, but on an intermediate sleeve, a method which relieves the spindle of a direct pull, making the feeding easier, and preventing the "whipping" action that may cause fracture of the drills. The sleeve is supported in the upper arm of the machine. The pulley boss is very long, and a feather key is fitted into its upper portion, over which the key-groove cut in the spindle slides in its vertical movements. The spindle is continuous, the feed being imparted through a rack and pinion. A head sliding on the face of the upright of the machine carries the pinion, and its shaft.

Fig. 282 is an illustration of a heavy spindle for a radial drill, a design far removed from that of a high-speed sensitive machine. It is divided into two portions, the rotating drilling spindle below, and the feeding spindle above with its rack and pinion, united through a screwed bush, and end thrust through friction washers for which a lubrication channel is provided. The rotation of the spindle is through a train of spur gears, actuated by reversing

Fig. 283.

Fig. 284

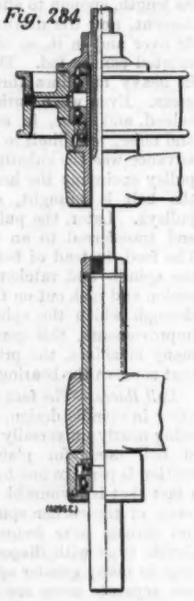
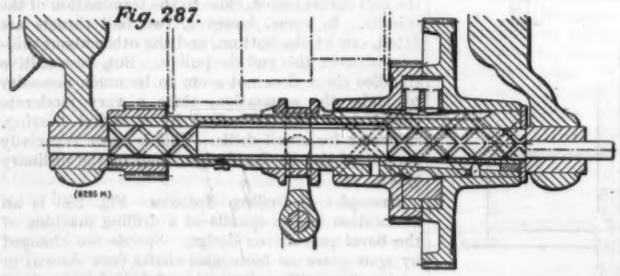


Fig. 287.



bevel gears on a horizontal shaft. The direction of rotation of the spindle can be reversed by the double-ended claw clutch seen. Its weight is counterbalanced with a disc that encircles a tubular casting which surrounds and encloses the rack-operated portion of the spindle. The weight is attached with cords, passing over guide pulleys to the top of the spindle. The rotating portion below slides through a quill, on the outside of which the double-ended clutch is feather-keyed, the spindle is also feather-keyed to the sleeve in the lower bearing. The bosses of the last pair of spur gears in the feeding train encircle the sleeve, and when the clutch is pulled up, or down into mesh with the jaws on either of the gears, the latter drives the spindle.

Fig. 283 is representative of recent practice in sensitive machines. The pulley is fitted with two radial ball bearings, the outer rings of which are secured in the bore, between top and bottom cap plates, and with a separating bush. The inner rings fit outside the sleeve that encircles the spindle, with freedom to slide, the upper cap is the transmission driving element, having two keys that fit the spline grooves on opposite sides of the spindle, so maintaining balance. The lower portion of the spindle is enclosed in a sleeve, with clearance, and runs at the bottom in a radial, and a thrust bearing. The outer races of the radial bearing are a push fit, but are free to accommodate themselves to changes in the length of the spindle. The races for the thrust bearing are between the inner radial race and the shoulder of the box, and the end of the sleeve. The sleeve and bearings are confined with locknuts above. The feed rack is cut on the sleeve.

The next Fig. 284 shows the application of Hoffmann races to the spindle of a sensitive machine. The pulley, driving the spindle through two splines, runs on a sleeve fixed in the upper arm of the machine. The spindle runs in a long lower sleeve, sliding in the arm there, and having a rack feed. Top and bottom bearings have separate ball and thrust races. The pulley has two radial bearings separated widely to afford ample support, and to ensure an even drive. Their outer rings are held tightly in the pulley bore in their separated positions, inner rings are a push fit on the sleeve, but have slight freedom of movement if the sleeve should expand with heat. The thrust washers are made fast, one on the sleeve and against its shoulder, the other in a recess in the pulley bore, but with clearance next the sleeve. At the lower end, the radial race has its inner ring fast on the spindle, and the outer is a push fit in its housing with freedom to slide endwise. The lower thrust washer, tight on the spindle, lies on the inner race, the upper washer is tight in a recess in the housing, with clearance next the spindle. The radial balls are $\frac{1}{16}$ in. larger than the thrust balls. All are enclosed in cages.

Milling Machine Spindles.—These are linked with those of the lathes on the one hand, and of the drills on the other. The horizontal spindles are allied to those of the lathes, the vertical with those of the drills.

Fig. 285.

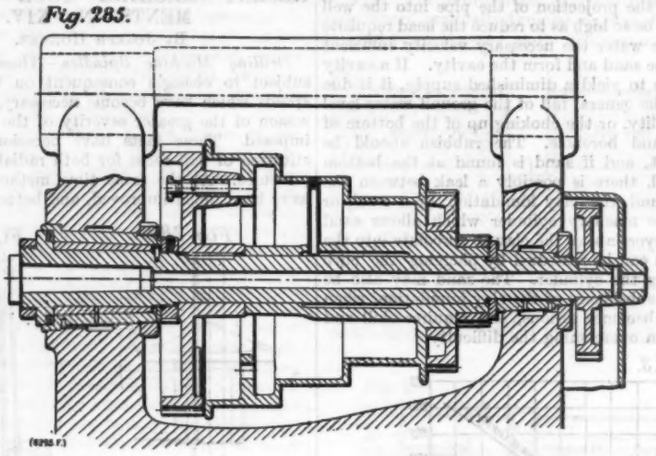


Fig. 286.

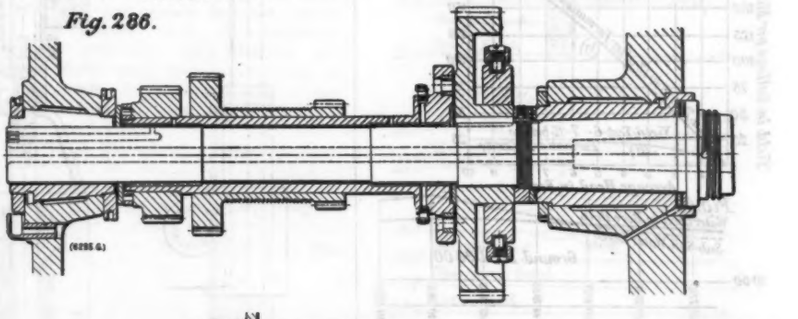
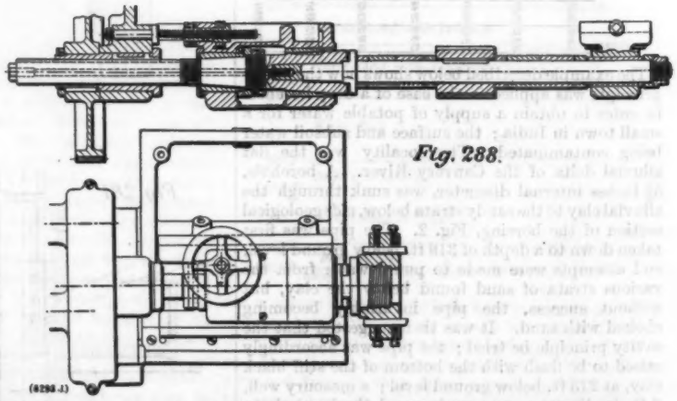


Fig. 288.



The main spindle of a heavy pillar and knee machine is shown by Fig. 285. The resemblance to the lathe is nearly complete, except that the spindle is hollow to receive a draw-in bolt for arbors. The spindle runs in a plain bearing, coned at the front, and a parallel bearing at the rear. Each has a locknut for taking up wear. Thrust is received on washers at the front of the front bearing. The fitting of the cone pulley and back gear is identical with that of common lathes. The front gear is keyed on the spindle, to be locked to the cone with a spring pin.

The main spindle of a heavy Brown and Sharpe milling machine is shown by Fig. 286. It is driven

through gears from the pulley shaft (not shown). Gears are slid into mesh by means of a pinion and circular rack encircling the sleeve on the spindle. The bearings are similar to those of lathes, with a coned journal neck in front, and a parallel one in the rear, with ring lock nuts for take-up. End thrust is received on collars enclosed at the front, next the nose collar.

Fig. 287 is the back gear spindle of one of the Le Blond machines. For it, the old eccentric throw-out is retained. But the two sets of back gears are put in and out with internal ring friction clutches. The eccentric spindle is encircled with a sleeve on

Fig. 289.

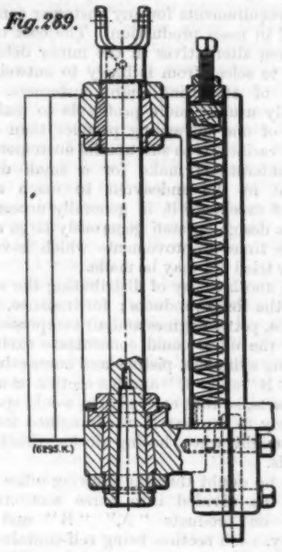


Fig. 290.

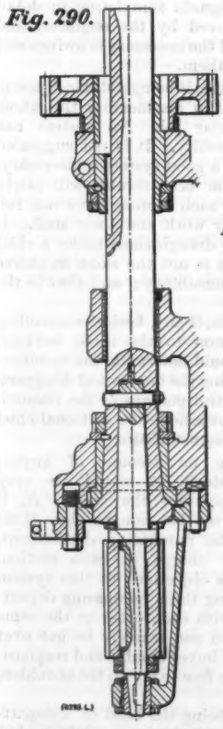
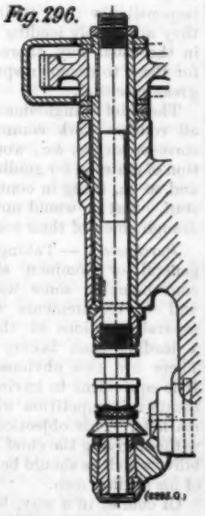


Fig. 296.



which the gears and clutches are mounted. Though the sleeve bearings are plain and parallel, they are very long, and diagonal crossing lubricating channels are cut on the journals. The method of putting either one of the back gears into mesh is with a doubly-bevelled dive-key, moved in either direction by the clutch, slid along the sleeve with a lever. When moved to the right it tightens the dive-key on the back of the wedge in the pinion, when it is slid to the left it tightens the wedge within the wheel. The double clutching mechanism comprises two rings slotted to receive the wedge blocks.

The spindle of a horizontal plano-milling machine is shown, Fig. 288, with a slabbing cutter mounted in the view above, and with a face cutter in the view below. The actual spindle is contained wholly within the slide, mounted on one upright. The extension in the upper view is an arbor fitted to the spindle at one end with a shank, of a standard taper, and a clutch, and running at the other end in a bearing in the opposite upright of the machine. A spline key for driving is fitted at the main bearing-left-hand. The spindle is driven through change

Fig. 291.

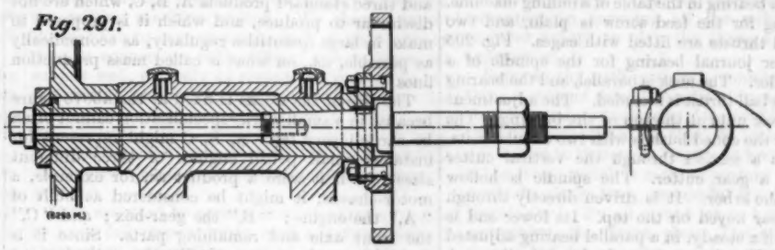


Fig. 292.

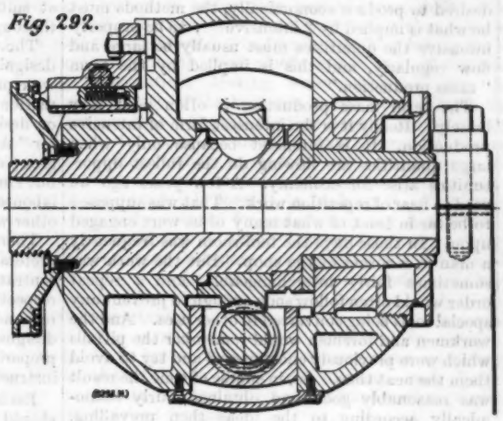
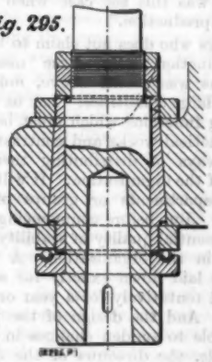


Fig. 295.



gears. Its main or driving bearing has double-coned journal necks facing outwards, both in the same direction. Take-up, provided for on the rear cone, also draws the front cone back. The spindle is hollow to receive a drawbolt, going to the end of the spindle. The maximum length of arbor is shown, which might be all occupied with slabbing, and gang cutters. Or, as drawn, with one of moderate length only, the supplementary portions of the arbor being occupied with a series of comparatively short make-up collars, all tightened with the nut at the right-hand end. The lower view shows the front elevation of the spindle slide, with a face milling cutter with inserted teeth mounted. It is screwed to a supplementary adapter that takes the place of the cutter arbor in the upper view. This example is from the design by Messrs. Darling and Sellers, Limited.

The method of supporting the weight of the spindle in a profiling milling machine by the Garvin Machine Company is shown by Fig. 289. The spring used for the purpose is enclosed in a tube. Its tension is regulated by the screw at the top. The former pin is seen below clamped with screws. The spindle runs in plain bearings, coned below, parallel above. A universal joint connects to a telescopic shaft from the countershaft.

The spindle shown in Fig. 290 is from a heavy vertical milling and profiling machine. The bearings are carried on a saddle that is supported on a cross-rail. The lower bearing support has vertical movements through a screw, to follow the cutter, and thus avoid overhang and consequent deflection. The lower journal bearing for the spindle is doubly coned, like that of many lathes—a low-angled cone

Fig. 293.

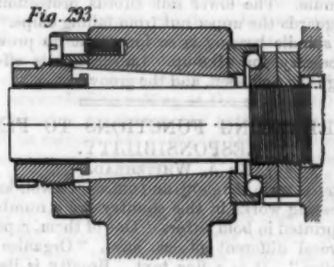
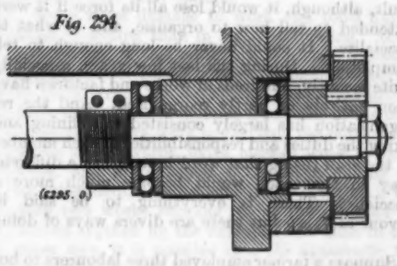


Fig. 294.



terminating in a short, steep one, to lessen risk of seizing. It is adjusted with lock nuts. The nose is bored to a standard taper for cutters, fitting also with a clutch. A support is provided for the lower end of the cutter arbor, being bolted up to the bottom bearing. The spindle is carried in a parallel bearing immediately above the cone, and again in another at the top, through which the splined portion passes. The rotation is derived from bevel gears (not shown), with a reversing clutch, thence through spurs, the last gear in the train being keyed on a sleeve that encircles the spindle, and carries the key over which the spline slides. The sleeve is secured endwise with locknuts.

Miscellaneous Examples.—Fig. 291 is an example of a spindle that is subjected to practically no wear. It is that for the dividing work-head of a gear cutter, which carries the work-arbor, and is only turned for the indexing, and when making preliminary adjustments. It has parallel bearings at each end, adjusted by closing in the split bosses, carries the dividing wheel at the rear, and a faceplate at the front. It is hollow to receive a drawbolt, to pull the arbor in and secure it, and has its nose bored to a standard taper.

Fig. 292 is typical of the group that comprises the dividing heads used on Universal milling machines. The spindle has long bearings in the swivelling head, being tapered at the front in the solid metal, parallel at the rear in a tapered bush. Wear is taken up between these through the clamp ring at the right hand, which secures the spindle endwise. There is practically no wear on the spindle, since its rotations are only for the purpose of indexing. This is provided for directly, for low numbers by

the index plate at the left; and by the worm, and its wheel that encircles the spindle, these being actuated from an index plate (not shown) for fine divisions and spiral work.

Fig. 293 illustrates an unusual form of adjustment for a parallel lathe journal neck. The cone is thrust along in its seating through the ring nut with an internal collar in the end of the cone, being itself encircled with a locknut threaded over it, the nut being secured to the head with a screw. Thrust is taken on a ball race at the rear, without cages, the balls running between a seating registered into the head, and another formed in one of the locknuts. Fig. 294 is a bearing in the table of a milling machine. The bearing for the feed screw is plain, and two double ball thrusts are fitted with cages. Fig. 295 is the lower journal bearing for the spindle of a vertical miller. The neck is parallel, and the bearing plain, but a ball thrust is included. The adjustment is by the lock nuts at the top of the bearing. The take-up for the coned bush is with two circular nuts. Fig. 296 is a section through the vertical cutter spindle of a gear cutter. The spindle is hollow to receive the arbor. It is driven directly through the spur gear keyed on the top. Its lower end is supported in a steady, in a parallel bearing adjusted with nuts. The lower nut affords protection. A hood guards the upper nut from falling chips. The main spindle bearing is so long that no provision is necessary for take-up. Lubrication is effected through the hole seen, and the groove.

ARRANGING FUNCTIONS TO FIX RESPONSIBILITY.

By A. Whitehead.

Displayed in the shops and offices of a well-known engineering works in this country are a number of texts printed in bold letters. One of them, repeated in several different places, says, "Organise and Specialise." It is a fine text. Brevity is its sole fault, although, it would lose all its force if it were extended to tell how to organise, and in what to specialise. It could never be long enough to tell completely. During the last few years, especially quite recently, hundreds of works and factories have been entirely or partly reorganised. And the reorganisation has largely consisted in defining and fixing the duties and responsibilities of each member of the staff (using that word broadly) in a different way so that each would become much more a specialist. There is everything to be said in favour of this; but there are divers ways of doing it.

Suppose a farmer employed three labourers to hoe a 3-acre field; they might mark the field off into three equal parts and hoe each his separate acre. That would be unsociable, but each would carry the responsibility for the part he hoed. Again, they might, actually of course they would, work in company side by side, so that although each would hoe one acre as before, it would be very difficult to say which man was responsible if patches of weeds showed here and there soon after they had finished. The work could be divided up in yet another way by instructing each man to specialise in different kinds of weeds. For instance, if the field were infested principally by thistles and docks, one could concentrate exclusively on thistles, the second on docks, and the third man, who would naturally let the others precede him, all the other weeds. If this way were followed, the first two could always shirk responsibility by alleging that they had done their duty, but that the third man had undone their good work. All would suffer, however, by this plan, because each one would have to go over the whole of the 3 acres. This seems fantastic, yet some so-called 'modern" methods of dividing up responsibilities or duties are of the same kind; they cause specialisation to take place in unnatural ways along unnatural lines. A man may specialise in a small field, but study everything within that field; or he may study only certain phenomena in a large field. The total amount of knowledge arrived at might be about the same in both cases, and different individuals would prefer some one way, some the other. But the man who specialised narrowly in a large field would find it very hard, he would find it impossible, to restrict his attention and thoughts solely to the prescribed phenomena. He would be not only tempted, but compelled to observe and study the numerous other phenomena which were present and active in effect on his special subject; so that unless he had more than ample capacity, he would be likely to fail to specialise and work effectively at all.

Therefore, in arranging the functions of technical staff, foremen, &c., it would seem desirable to give each a field suitable to his capacity, and to require him to know everything in that field thoroughly well. But the boundaries must be definite. To make the meaning quite clear we will consider a works having between 2,000 and 3,000 employees, and three standard products A, B, C, which are not dissimilar to produce, and which it is proposed to make in large quantities regularly, as economically as possible, i.e., on what is called mass production lines

The size of the works is fixed at the above figure because in a small works specialisation cannot often be carried very far. A, B, C might represent for instance small petrol engines of three different sizes; or if it were a product as, for example, a motor-chassis, it might be considered as built of "A," the engine; "B," the gear-box; and "C," the front axle and remaining parts. Since it is desired to produce economically, the methods must be what is implied by "intensive"; to be properly intensive the quantities must usually be large and flow regularly, and this is implied by the term "mass production."

The term mass production is often used very loosely. Really it is the intensest form of intensive production. It is intensest because only when large quantities are flowing do the fullest opportunities arise for economy. A few years ago we used to hear of repetition work. That was supposed to be far in front of what many of us were engaged upon. In those days the tool-room was frequently a man in a corner of the shop. But the work was sometimes fairly interchangeable, and a repeat order would often follow soon enough to prevent any special tools being converted to other uses. And the workmen and foremen would remember the pitfalls which were previously encountered and try to avoid them the next time. So, in course of time the result was reasonably good and obtained fairly economically according to the ideas then prevailing. Especially was this the case when we got on to "quantity production."

Nowadays who does not claim to be an expert in mass production? But true mass production involves, as was stated above, much more than producing large quantities. Let us select some of the leading functions which must be performed in the hypothetical works and contrast the effects of different ways of distributing them among the members of the organisation. It will be convenient to take departments or groups of departments separately. But before commencing let us assume that the essential quality of stability is not lacking anywhere in the organisation. A programme of production laid down exactly for several months ahead, and tentatively for a year or two ahead, is necessary. And the design of the products must not be liable to sudden changes in any part. In other words, the directors of the company must have a disciplined, stable policy.

It takes longer to train even a slightly-skilled operator than some people would have us believe; the difference in effectiveness between equal volumes of labour employed at different works is much more due to differences in the spirit of the administration than to differences in the natural abilities of the workers. Stability is the prime essential; without it there can be no healthy development.

Drawing Office.—The functions of the drawing office may be divided broadly into designing, the preparation of working drawings, and issuing part lists and other instructions to the departments which set production in motion. These functions are quite distinct, and are sometimes carried out in separate offices. For mass production those responsible for design should have an extraordinary knowledge of workshop practice and the different methods of manufacture now available. Therefore it is desirable, one might say essential, for them to be in direct contact with the workshops and not to learn of the difficulties which arise at second or third hand through the other offices, which, in fact, if not in theory, would be more in touch with the works.

There are some small advantages in making the offices separate, for instance, in designing in one office, and preparing workshop drawings in another; but the overlapping and duplication of work which separation involves quite overbalances them. The natural way of distributing the designing of products A, B and C, is to give "A" to one section, and "B" and "C" to different sections, each being under the direction of a leading draughtsman or designer who is responsible either directly or through the chief draughtsman to the company's engineer.

Special requirements for any customer cannot be thought of in mass production. The cost of even two or three alternatives in the minor details for customers to select from is likely to outweigh the advantage of attracting more customers. It is undoubtedly usually more profitable to make and sell fewer of one unvarying product than to sell more with variations to suit special customers. All these considerations make for a small drawing office. But in the endeavour to reach a high standard of excellence it is generally necessary to maintain a designing staff generously large so that at suitable times improvements which have been thoroughly tried out may be made.

There is another way of distributing the work in designing the three products; for instance, if they were pumps, petrol engines and air compressors, one section of the office could concentrate exclusively on designing cylinders, pistons and connecting rods for "A," "B" and "C" another section on another group of parts, so that each section would specialise but similarly to the way it was imagined the three labourers might when hoeing docks, thistles and other weeds.

There is no doubt that the drawing office should preferably be divided into three sections, concentrating on products "A," "B" and "C" respectively, each section being self-contained and responsible so far as regards completing in detail designs generally approved by the engineer, and preparing and issuing all the necessary drawings and instructions concerning them.

Each of the three leaders, it being a stable concern, should be able to carry in his memory the whole history of his particular job. No system can replace that valuable faculty. It is not suggested that memory can make a good system unnecessary. It is claimed that the best results will rarely be got if the chiefs of each section have not full responsibility over their work and their staff. If they are simply leading draughtsmen under a chief in the usual way, there is not the same incentive for them to accept responsibility; and that is the great essential.

The chief draughtsman, if any, besides controlling all routine work common to the three sections, correspondence, &c., would determine the specification of material for guiding the buyers and designers, and so on, being in control perhaps of the research staff. But he would not relieve the sectional chief draughtsmen of their responsibilities.

Purchasing.—Taking no account of buying general or common stock, it would be very convenient in some ways for the special A, B and C requirements to be bought by three separate sections in the purchasing department, a leading man taking charge of each section. There are two obvious objections to this system It is equivalent to having three purchasing departments in competition with each other in the same markets. This objection can scarcely be got over without giving the chief buyer trouble and responsibility which he should be free to lay on the shoulders of his leading men.

Of course, in a way, being the head of a department he must carry the whole responsibility; but essentially it must be delegated very definitely by him among his subordinates, and it is the manner of doing this which is to be considered. The other objection is, that each of the three buyers would need to be of far higher calibre than a different arrangement makes essential. Providing the drawings and specifications are definite and clear, the chief of the whole department has a good technical knowledge, as well as business experience, and directs

the organisation well, the details of buying can almost entirely be reduced to routine clerical work. Quantity, quality, dates and rates of delivery being properly scheduled for the week or month for a suitable period ahead, and the inspection of materials as they are received being prompt and adequate, relieves the subordinates from the necessity of having any technical knowledge beyond the amount required to understand the specifications and other instructions given them. The whole requirements of the works can be covered by grouping them according to their kind, not to their purpose. Suitable lists and schedules must be arranged accordingly specially for the department, but that is not a great objection for mass production, because the infrequent changes allow clerical errors or omissions to be discovered early and eliminated.

By making one man responsible for buying, for instance, all the castings, another all the copper wire and insulating material, and so on, according to the particular kind of manufacture, responsibility is definitely fixed in a suitable way. But what does "buying" include? Will a buyer consider that he is not a chaser, and that urging material is routine work to be done by the clerk whose speciality that is (although in special cases to which his attention has been drawn he will oblige by willingly taking an active interest)?

Certainly it is reasonable to delegate the functions so that one man makes a speciality of worrying suppliers the moment they fail to keep their promise. But what happens if the man who placed the order is thereby relieved of the least responsibility? The one will say, "I have placed the order; I have done my bit." The other can maintain that, "We placed our orders with such rotten people. When everything is overdue how am I to distinguish which is most urgent? Anyway, I should have reached that drawer to-morrow." It is altogether simpler and better to make the man who places the orders carry the whole responsibility until the materials are accepted. There is no need for him to spend a lot of time in searching through little drawers full of cards. He needs to take broad, rapid views, and charts for this purpose are in every way superior to cards. The urging letters or other communications which he is likely to compose will be more effective than stereotyped memoranda from one lacking his definite knowledge. And there is a very great advantage in each leading man maintaining his own charts; by so doing he soon memorises the essential facts and thereby can use his energy to better advantage than if he had to seek information in records before every move; and if the charts are properly constructed he can hardly miss any item.

Briefly tabulated then, the *personnel* of the department would consist of: The chief; leading men responsible for buying one particular kind or group of materials (buying being defined in accordance with the preceding remarks); a general staff of typists and clerks to carry out the routine work under the direction of the leaders, some being attached to one, others performing specific duties common to the needs of all sections in the office, as found expedient.

The above disregards some work which falls within the scope of purchasing, but roughly it indicates the functions of those actively engaged in buying. To retain simplicity the scheme depends very much on well-designed charts, working strictly to sanctions in ordering materials, and genuine, continuous mass production. Unlike the drawing office, the purchasing department is best run as one unit, not three or several, and the man who buys castings for example, shares with others the services of the general staff in the purchasing office, although his individual responsibility (to his chief) to procure castings of the right kind, at the right price and at the right time is shared with nobody.

The Machine Shop being much more complex than the departments already considered, there is far greater opportunity for varying the organisation. Grouping the machines in several different ways is possible, and each way alters the functions of some of the staff responsible for running it. The word staff in this sense is used broadly to indicate those above the rank and file, whether they are paid a salary or an hourly wage.

The machines can be grouped according to their class or species, and this is the common way. Or the machine shops can be divided into three self-contained units, one for each product A, B, C. Or grouping can be carried out so that there are a number of small sections, each section being self-contained and complete, and devoted to producing a particular kind of component; as an example, there might be a cylinder section, a crankshaft section, and so on. Or there can be a mixed arrangement of two or more of the above.

In the first way, the grouping of machines together according to species, the foreman over each genus is often a lifelong specialist. Consider, for instance, the milling machine section. We should expect the foreman to have spent the bulk of his workshop time in connection with milling, and to know his subject well, not only as regards his own shop, but by reading and intercourse with others, in a far wider sense. In a works employing 3,000 people it is likely that the milling shop would be too large for one foreman to supervise efficiently without assistance. What form then should the assistance take?

If an assistant be appointed it is desirable for him to have full responsibility over a definite part of the section rather than partial responsibility over all, otherwise he will not have a fair chance to be really efficient. The frequent striking inferiority of assistants to their chiefs is a matter of common observation. Making every allowance for the tendency of the best men to rise eventually to the top, it is still probable that most of the inferiority is due more to atrophy than absence of natural ability; which is another way of expressing the common opinion that it is much harder to obtain a well-paid job than it is to keep it. The prime quality essential for undertaking any staff function successfully is that of accepting responsibility. We know that many always will evade it, but most have to be trained to it either from infancy or later in life. Training implies exercise. What real opportunity of exercising responsibility is a man who merely assists often permitted to exercise? It is better to appoint a convenient number of charge hands under the foreman, each having definite responsibilities over a small section, than an assistant foreman.

All the work which passes through the department must have the processes planned out in detail, with milling playing its proper part as one in a team. This planning would, of course, be done to ensure efficiency as a whole, nothing being sacrificed for the convenience of any single department. The milling foreman will be invariably consulted in every point where milling enters, partly to obtain his technical advice and partly to provoke his interest and good will.

Being a specialist it will often be difficult for him to take broad views outside of milling. Yet, when discussing the method of machining any part, it is usually desirable and often necessary to know exactly the functions of the component under consideration. So that because the foreman has specialised in a certain way, his value as an adviser is very likely less than if he had enjoyed a broader training. And this applies to most of the other specialists associated with him. When we read, or are otherwise informed, of the remarkable results which are being obtained in production by using certain specialised methods, it would be very interesting to know the men responsible. It cannot be denied, it is obvious, that specialisation is necessary; it is the manner of doing it we are considering; and the mere fact that such and such a firm is extraordinarily successful does not prove that the system they employ is the cause of it, although it probably is a help. Success in such a case, if the cause of it could be known, one may be quite safe in asserting, is mainly due to the genius of an individual in a controlling position who counts for far more than any system.

With some systems this milling foreman has prepared for him all the tools and gauges with which to do the work; the machines all selected, and possibly speeds and feeds decided as well independently of him. It being mass production probably the bulk of his machines are run continuously without changing the set up, year in year out, but some of the machines on quick operations are changed occasionally. Is it a true description to name him the milling shop foreman? Except that he requires some knowledge of milling, rather more indeed than most of his men, to preserve his prestige, it would seem to matter little whether they are milling machines or chaff cutters he supervises. Of course, lots of little troubles occur which he has to deal with and overcome, but not well, or easily, or quickly, unless he departs from the narrow functions he is supposed to fulfil; and that is one reason why it is possible to have a system which seems good, modern methods in the shops, and yet to lose money. Any way, there seems to be little advantage in grouping all the milling machines together except to give the shops a neat, orderly appearance.

Suppose the milling shop is running with everything "cut and dried," the drawings and lay-outs as complete and up-to-date as it is possible to get them, tradition established so that all little "wrinkles" are known to those who require to know them, what is the factor which is more important than brilliant methods, clever tools, wonderful speeds and feeds? Regularity! By all means let us have the best of everything, the finest plant, the airiest, lightest shops; but, for economy, nothing counts quite in the same way as regular, steady, unbroken running.

For instance, if a milling operation can be done at the rate of 120 an hour by changing the cutters for re-sharpening about every 5 hours, would that be as economical as milling at the rate of 100 an hour and having to change the cutters once a week? Let us assume that changing the cutters causes on the average a stoppage of 20 minutes every time. In round numbers the outputs would be 5,000 and 4,500 a week, which seems clearly in favour of 120 an hour; a view which the cost office would heartily approve as being the correct one. Yet, if the real indirect charges could be reckoned it might alter their opinion.

Much more damage to work and tools happens when re-setting than in straight running; the far greater risk of this occurring, the huge increase in the amount of cutter grinding (which is equivalent to transferring the milling to the cutter-grinding department), the proportional increase in the outlay on cutters, extra work in carrying the cutters backwards and forwards, extra clerical work in several ways, and extra supervision in the milling shop and elsewhere, makes such a difference, that if there were two works running under the different conditions typified by the example, but alike in every other way, it is possible that the apparently more successful, swifter producing works would be the less profitable. If special setters were employed to exchange the cutters instead of operators doing it themselves there is very little doubt about it; but the example is only given to illustrate one advantage of continuous running. It is not professed that all the factors which have to be reckoned with have been included.

The point is, is this specialist whom we call the milling shop foreman in a position to command regularity when he is given so little power to control? Does his position not resemble that of the third man in the illustration of three men hoeing a field?

Perhaps the time quoted above, 20 minutes for exchanging cutters, may be thought too high for an average time. It is, providing there is always a supply of re-sharpened cutters ready, which there is sure to be if there are plenty in use, and a large cutter-grinding department for the work it has to do, and everyone is anxious and willing, and not prevented by other urgent business from attending to this one little job.

In ideal mass production the progress of any component through the shops should be exactly to a pre-arranged schedule. But in practice it is, of course, impossible to get such perfect balance, and break-downs from some cause or other are inevitable occasionally.

Progress men in these circumstances cannot do more than call attention to the weak production of those parts which are not coming through in sufficient quantities; they seldom have the qualifications for removing the trouble. And what real personal interest has the foreman who is running this large milling shop in the fate of any particular component?

THE BAGHDAD RAILWAY.

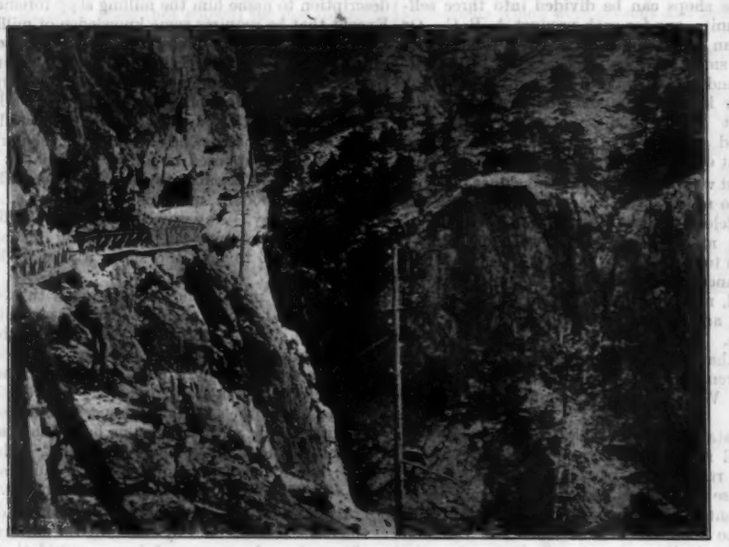


Fig. 1. Temporary Road; Taurus Tunnel Section.

Fig. 2. Hadji-Kibi Viaduct Completed.

No doubt he is anxious for his own reputation and the prestige of the shop he supervises; he desires to please his superintendent, and the progress man may be a particular friend of his whom he would be glad to oblige. But on the whole, he is forced to take a general, not a particular view, and if there is a stoppage reported to him which can be removed only with the assistance of some other department, what is there to stir his enthusiasm, and to infuse others with it, causing them also to take swift, effective action? The universal experience is, that a foreman under such conditions, if he be a new man, will be tolerated at first, in spite of his enthusiasm. But after a time, discovering the truth about the pleasant inertia of those of equal rank to his own in other departments, he becomes as they, or bitter and unpopular when he has found his level. For him, any milling operation is only one among hundreds for which he is responsible. If it happen that the job be such that a group or a chain of his own machines on successive operations will be brought to a standstill, he is likely to bestir himself so that some decisive action to prevent the trouble developing is taken. But this is because he can grasp enough to appreciate the magnitude of the misfortune. In practice, there is frequently no decisive action taken until trouble has come, and succeeding operations are starved, if not completely stopped. The full extent of this kind of loss is not readily apparent by walking round a works, because the stoppages in successive operations may not occur simultaneously; there may be several weeks interval from the time the stoppage occurred in an early operation on any particular job, until the effects in succeeding operations have completely disappeared.

(To be continued.)

THE BAGHDAD RAILWAY.

To the public, the title "Baghdad Railway" has always been misleading; suggesting a complete new scheme for a line from Constantinople to Baghdad; whereas the line of the Anatolian Railway reached as far as Konia, the old Ottoman capital, before the extension to Baghdad was contemplated. At the time of the armistice, in 1918, the Anatolian Railway was completely separated from the Baghdad system, for which the British War Office appointed a Controller-in-Chief, to organise and control the whole line from Konia to Baghdad.

The Pan-German conception of Eastern expansion had, as its principal idea, this trunk line towards the Persian Gulf. The history of the project, and its great political, financial and especially engineering difficulties, not only under German management, but under the subsequent direction of the Allies, will provide, in the future, a rich field for reference and comparison, in all similar undertakings. The scheme was a pet idea of the German Kaiser, who took a keen personal interest in it, and even went so far as to order the construction of a special train to convey him to the opening ceremony at Baghdad, which it was assumed would take place in 1918.

In 1903 the Ottoman Government granted a concession for construction, to a group of financiers, headed by the director of the German Bank, von Gwinner. The Ottoman Bank in Paris was also largely interested in the project which, as a commencement, only contemplated the construction of 200 km. of line from Konia to Bourgoulow. For this a Construction Committee was formed, and the work completed by the end of 1904. It was not till 1909 that the Ottoman Government agreed to the construction of 800 km. of line, up to Tell-Helil, near Nisibin. In this year a new Construction Committee, under the title "Société pour la Construction des Chemins de Fer de Turquie," was created by the Baghdad Railway Company, with headquarters at Glarus, in Switzerland. A Board of 12 members was appointed to control the new construction, and consisted of five German members, four French, two Swiss and one Austrian. The Baghdad Railway Company defrayed the cost of the construction, 9 per cent. being allotted as profit to the Construction Committee. The offices of this committee were in Frankfurt-on-the-Main.

Three divisions were created in Turkey under the direct supervision of the Frankfurt Committee. The divisions were as follows: No. 1, from Bourgoulow (km. 200) to Dorak (km. 329), comprising the Taurus Tunnel sections, which formed the most difficult and important part of the whole undertaking. This was placed in the hands of Mr. N. Mavrogordato, an engineer of international repute, and wide experience. The difficulties encountered on this section will be dealt with later.

No. 2 division, was from Dorak (km. 329) to Islahie, in the Amanus mountain range. This included a large bridge over the river at Adana. It also included many tunnels through the Amanus range, the longest of which measured 4,902 m. The chief engineer was Mr. H. Winkler.

No. 3 division extended from Islahie to Tell-Helif, and comprised the Aleppo division. Near Aleppo a steel viaduct was constructed, 800 ft. long, 450 ft. high; a very graceful, but apparently very light structure. In this division was also the great bridge over the Euphrates at Jerablus, with 10 spans of 165 ft. each, and a total length of about ½ mile.

Later on, a fourth division was made at Baghdad, after the Turkish Government had consented to the construction of the line as far as that town. The chief engineer of this division was Merione Pacha.

Until the Balkan War of 1912, the work progressed very well. Up to this time, two issues only of the Baghdad Loan had been made, or about two-fifths of the entire sum. Subscribers were, however, not to be had for the third issue in 1912. Lack of money prevented the Construction Committee from carrying on the works at the former speed; and this financial difficulty continued up to the outbreak of war in August, 1914. Nearly all the works were then stopped, with the exception of the Taurus and Amanus tunnels, and the great Euphrates Bridge. When the Turks, at the end of 1915, came into the war, the German Government, realising the importance of this railway for carrying on the campaigns in Asia Minor and Mesopotamia, made the Turkish Government come to an agreement with the Baghdad Railway Company to continue the works, and complete them as quickly as possible. The Turkish Government did not want a Decauville line to be built first, but wanted the broad gauge (4-ft. 8½-in.) construction pushed as soon as possible, through the Taurus and Amanus ranges to Aleppo. All the expenses, as long as the war lasted, were to be refunded to the Baghdad Railway Company, with a percentage for the committee, without the limit laid down in 1909. This contract between the Turkish Government and the Baghdad Railway Company did not meet with the approval of the German Army Headquarters Staff; which made a new contract with the company, by which the German Government undertook to furnish all the money required, as a loan to the Turkish Government, and thus guaranteed the payment of the money for building, and the percentage agreed to in the Turkish contract. It was insisted, however, that the work should be pushed on in such a way, that a narrow-gauge railway (60 cm.) should be laid right through as early as possible; and that the broad gauge should be continued, after the narrow gauge had been made fit to carry traffic.

These narrow-gauge lines through the Taurus from Karapunar to Dorak, and through the Amanus to Islahie, were completed by the beginning of January, 1917. They made a very great difference in carrying on the war in Mesopotamia and Palestine. By transferring only it became possible to convey war stores and material to both battle fronts by rail, whereas previously motor and horse transport

THE BAGHDAD RAILWAY.

Fig. 3. View of Line at the North End of the Taurus Tunnel Section.

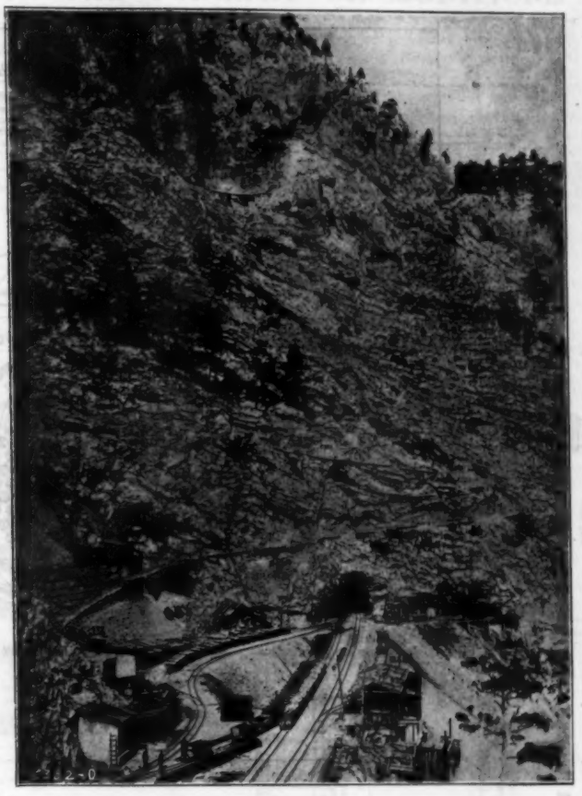


Fig. 4. Eastern End; Taurus Tunnel Section.

had to be employed, over dangerous and precipitous roads and tracks.

The broad-gauge line was only finished on the Taurus Tunnel section on October 5, 1918; and as the British occupation of Aleppo was effected on the 24th of the same month, the Turks and their allies gained little benefit from this great engineering feat, to the completion of which some thousands of British and Indian prisoners-of-war had contributed, under conditions which, to say the least, left much to be desired.

The following details show the progress and position of the undertaking, to date: The distance from Konia to Aleppo, which is the junction for Palestine and Egypt, is 666 km. From Konia to Nisibin, which is at present the furthest railhead towards Baghdad, is 1,101 km. To Mosul, up to which the earthworks are completed, is 1,300 km.; to Baghdad the total distance is 1,749 km. The railway has been constructed from the Baghdad end, northwards, as far as the oilfields at Shargat, so that only a gap of about 175 miles or about 280 km. remains to complete the through communication between Baghdad and Constantinople.

Permanent Way.—The rails are 37·42 kg. per metre, and the line is a single track, gauge 4 ft. 8½ in. The Taurus summit is 1,468 m. In the Taurus division there are 36 tunnels in 62 km. In the Taurus Tunnel section proper there are 11 tunnels, of an aggregate length of 10,036 m., the longest being 3,795 m. Near Bagtche, in the Amanus, there is the long tunnel, already mentioned, of 4,902 m., with a summit level of 741 m. The minimum curvature is 400 m. radius, or about 4° 30′.

Grades.—In the first 210 km. from Konia the grades do not exceed 1 per cent.; but on the ascent to the Taurus summit, there are 13 km. of 2½ per cent., and on the descent there are several short lengths of the same grade, extending over a section of 45 km. A second section of 50 km. near the Amanus mountains has also grades of 2 per cent. and 2½ per cent. Between Aleppo and Nisibin the grades do not exceed 1¼ per cent. Owing to these abnormal grades, the working of this part of the line is difficult, and not economical. A much better line could have been located nearer the sea, avoiding the Amanus range; but this was not done, for strategic reasons.

Telegraphs.—There are four lines for the whole distance, and telephone in addition.

Workshops and Sheds.—The main workshops are at Konia, Adana and Aleppo. There are round-houses at Karaman, Eregli, Adana, Mamonu, Alexandretta, Monolimic and Aleppo, and smaller engine sheds at Bozanti, Tarsus, Toprak Kale, Meiden Ekbese Tel Abiad, Ras-el-Ain and Nisibin.

Stations.—There are 70 stations, an average distance apart of 16 km. They are built of dressed granite, with tiled roofs, and are of excellent construction.

Rolling-Stock.—The locomotives are all of German heavy-type construction; which is necessitated by the heavy grades. The coaches and wagons are of the latest bogie type.

Traffic Capacity.—The traffic capacity is eight pairs of trains per day between Konia and Aleppo; eight pairs of trains per day, between Aleppo and Ras-el-Ain; four pairs of trains per day, between Ras-el-Ain and Nisibin.

The photographs which we reproduce on the present and opposite pages, and on page 184, give some idea of the great difficulty of locating and constructing the railway, in the Taurus Mountain Division.

Fig. 1, on page 174, is a view of the temporary road used in the construction of the Taurus Tunnel section; 5,000 men worked a year to complete this road. Fig. 2, on page 174, is a view of the Hadji Kiri Viaduct, 900 ft. long, 460 ft. high. This was to have been constructed of light steelwork, but as that material was not obtainable during the war, it was decided to construct it in ferro-concrete. No scaffolding, only centering, was used, all materials being carried and placed by an air line. Another view of this viaduct is given in Fig. 5, on page 184, showing it under construction. Fig. 3, annexed, is a view of the railway skirting the mountain stream at the north end of the Taurus Tunnel section, while Fig. 4 shows work in progress on a typical tunnel on the same section. Fig. 6, on page 184, is a view of one of the typical connecting viaducts between the tunnels of this section. Fig. 7, on the same page, shows the construction camp at Belemedik, housing over 10,000 employees working on the Taurus Tunnel section, while the view in Fig. 8, on the same page, is of the 10-span bridge at Jerablus, over the Euphrates.

When taken over by the British control, absolute chaos prevailed on the railway. Much damage had been done to the permanent way, buildings and rolling stock. The Taurus Tunnel section needed completing, as the tunnels were unlined, while the permanent way, cuttings and banks were unfinished, and were not safe for traffic. All this work was put in hand at once, and was carried out chiefly by the Indian sappers and miners, who did most excellent work under very trying climatic conditions. That the railway, under efficient management has a favourable future, financially, is shown by the fact that, after payment of all construction and running expenses, during the first year that the line was under British control, a net credit balance of 350,000*l.* was obtained.

New Coal Discoveries in Germany.—At Lübeck, in Westphalia, some extensive deposits of coal have recently been discovered, and even if the annual production has been somewhat optimistically estimated, the deposits certainly appear to be very valuable. The location is favourable, and work could be commenced at a comparatively early date. The deposits in question are principally of gas coal.

2-8-0 TYPE SUPERHEATER LOCOMOTIVE FOR THE MINISTRY OF MUNITIONS.

CONSTRUCTED BY THE SWISS LOCOMOTIVE WORKS, WINTERTHUR, SWITZERLAND.

Fig. 3.

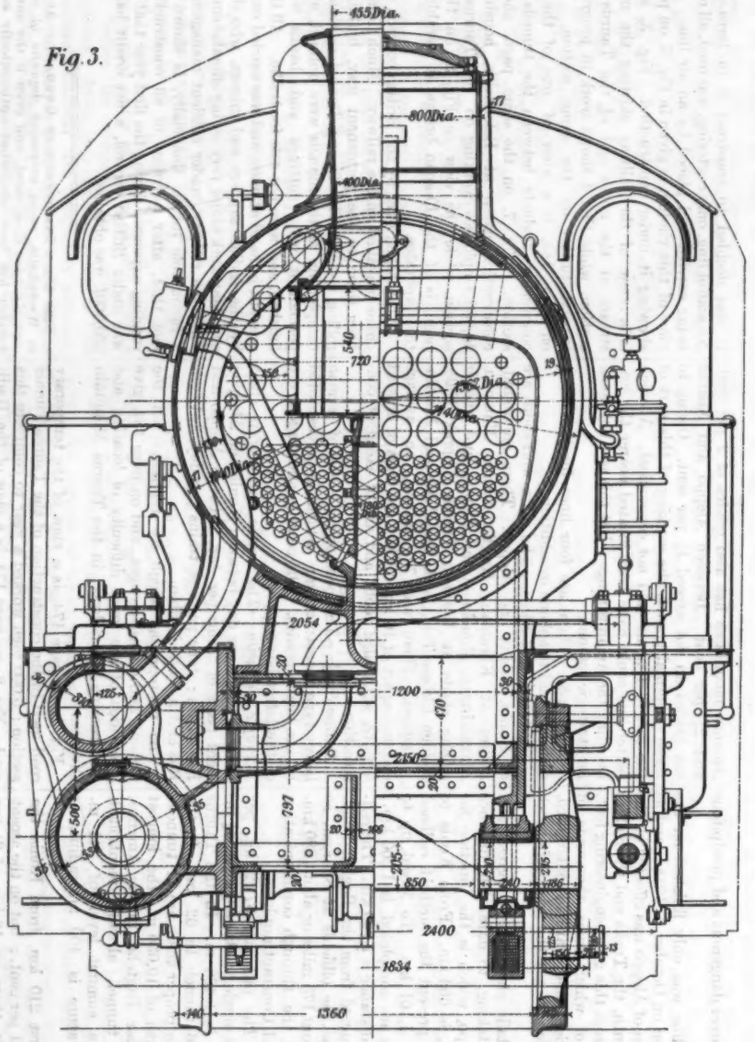
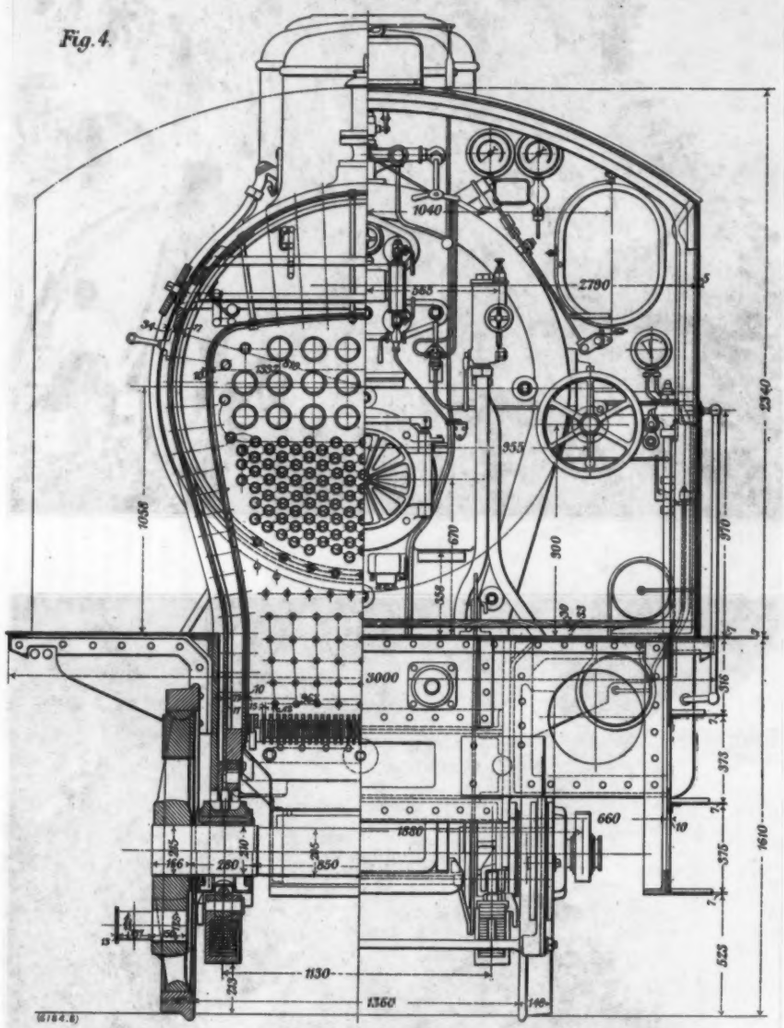


Fig. 4.



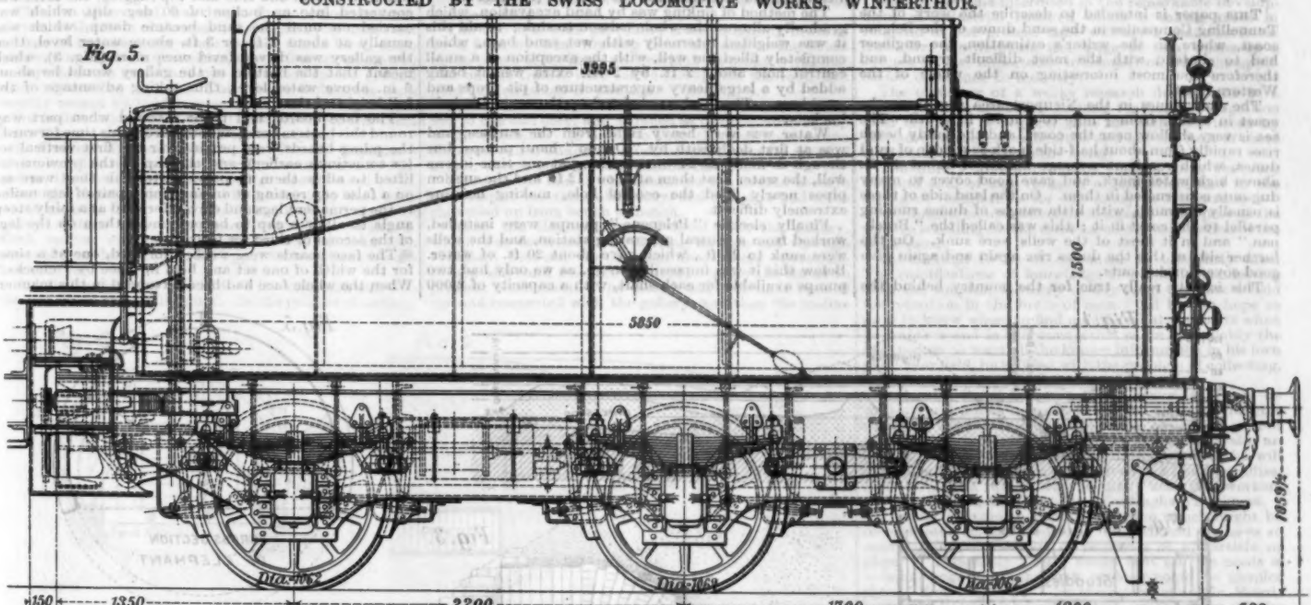
A CLASS of locomotives to which attaches an interesting history is illustrated in our two-page engraving Plate XX, with this week's issue of ENGINEERING, and in Figs. 3 to 7, on the present and opposite pages. Ten of these engines were ordered from the Swiss Locomotive Works, Winterthur, by the Ministry of Munitions, during the war, but were only completed about the time of the armistice, and were thus not required by us. They were therefore sold, the purchasers being the Czecho-Slovak Government, to whom they were delivered, instead of being sent to England. For some reasons this is to be regretted, as it would have been interesting to watch the behaviour in service in this country of a typical Continental product turned out from these well-known Swiss works. The design of these engines is based on the "C 4/5" Class locomotives of the Swiss Federal Railways. The engines are built to take curves of 105 m. (344 ft. 6⅜ in.) radius and under normal conditions to haul a load of 650 tons at a speed of approximately 40 m.p.h.

The cylinders are provided with piston valves with inside admission. The valve motion is of the Walschaert type. The boiler is fitted with a superheater, there being 132 boiler tubes of 2 in. diameter and 22 flue tubes of 5½ in. outside diameter. The Robinson superheater is fitted. A cast-iron rocking grate and brick arch are provided. The lateral movement of the leading truck is 4½ in. on each side. Side play to the amount of ¾ in. is also allowed on each side in the case of the second and fourth pairs of coupled wheels. The maximum axle load is 17½ tons. The Westinghouse brake is applied to all driving wheels. The other fittings comprise the Swiss Federal Railways type of air sander, steam heating apparatus, rail-washing apparatus, Gresham and Craven injectors, Wakefield lubricators, &c. It will be seen from Fig. 5 that the

TENDER FOR 2-8-0 TYPE LOCOMOTIVE FOR THE MINISTRY OF MUNICIPALITIES.

CONSTRUCTED BY THE SWISS LOCOMOTIVE WORKS, WINTERTHUR.

Fig. 5.



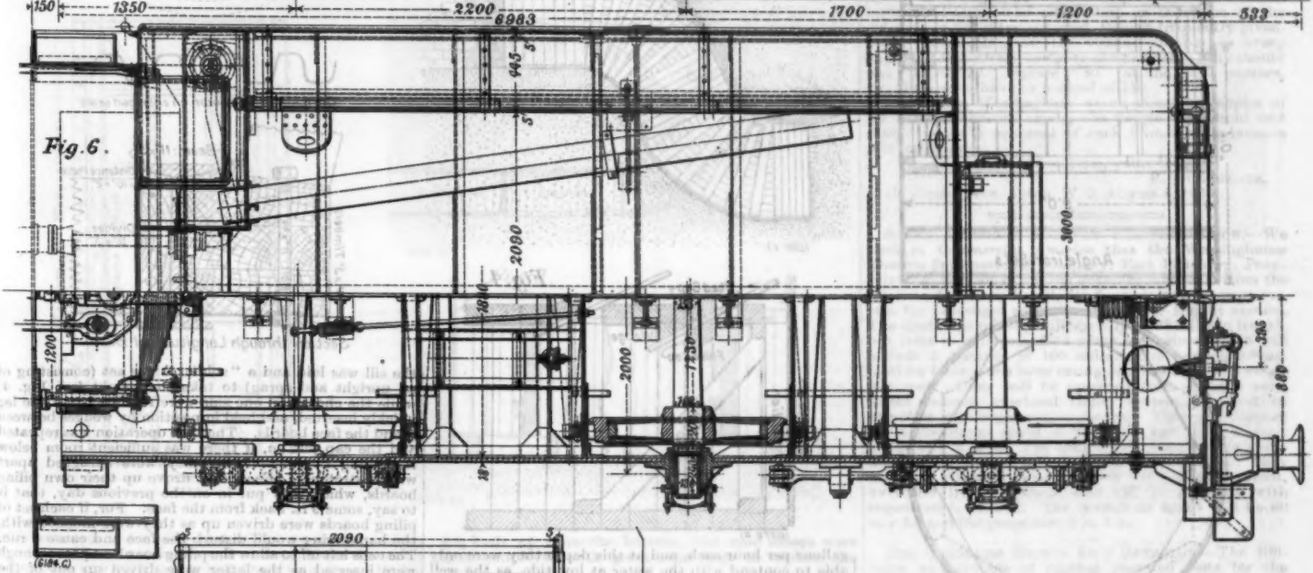


Fig. 6.

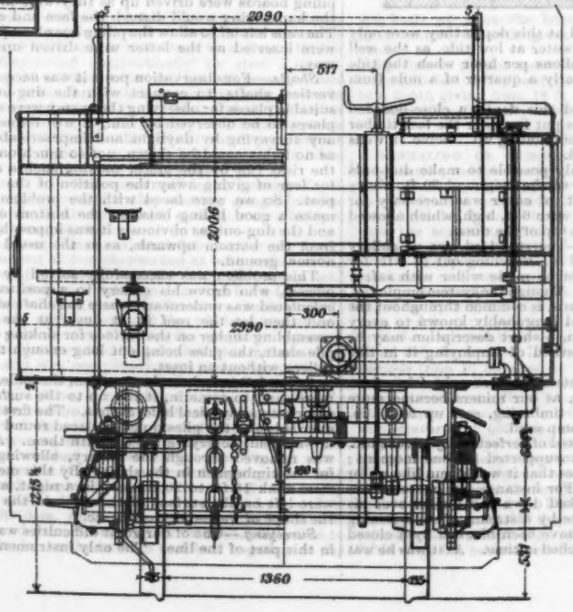


Fig. 7.

tender tank is provided with a water level indicator. The following are further particulars of the engine and tender:—

Engine.

Cylinders, diameter	21 in.
Cylinders, stroke	25½ in.
Wheels, driving, diameter	4 ft. 6½ in.
Wheels, leading, diameter	3 ft. 1½ in.
Heating surface, fire-box	159 sq. ft.
Heating surface, tubes	1,556 sq. ft.
Heating surface, total	1,715 sq. ft.
Superheater surface	308 sq. ft.
Grate area	27·1 sq. ft.
Working pressure	135 lb. per sq. in.
Wheel base, rigid	11 ft. 1½ in.
Length of engine	38 ft. 9½ in.
Weight on coupled wheels	60 tons.
Weight of engine, empty	65·4 tons.
Weight of engine in working order	71·4 tons.

Tender.

Wheels, diameter	3 ft. 5½ in.
Wheel base	12 ft. 9½ in.
Length over buffers	22 ft. 11 in.
Water capacity	4,000 gallons
Coal capacity	7 tons.
Weight, empty	16·5 tons.
Weight in working order	42 tons.

Engine and Tender.

Total length over buffers	59 ft. 10¼ in.
Total weight in working order	113·4 tons.

TUNNELLING IN THE SAND DUNES OF THE BELGIAN COAST.*

By Captain H. Tatham, M.C., A.R.S.M.Dic, Associate.

This paper is intended to describe the work of the Tunnelling Companies in the sand dunes of the Belgian coast, where, in the writer's estimation, the engineer had to contend with the most difficult ground, and therefore the most interesting on the whole of the Western front.

The sand dunes in the Nieuport area run along the coast in a belt, from ½ mile to 2 miles in width. The sea is very shallow near the coast, and the sandy beach rises rapidly from about half-tide mark to a ridge of sand dunes, which reach an average height of about 40 ft. above high-water mark, and gave good cover to many dug-outs constructed in them. On the land side of these is usually a swamp, with little ranges of dunes running parallel to the coast in it; this was called the "Brackpan," and in it most of the wells were sunk. On the further side of this the dunes rise again and again give good cover for dug-outs.

This is only really true for the country behind the Oust Dunkirk-Oust Dunkirk Bains road, as the "Brackpan" dies out in front of the road giving place to a third range of dunes between the other two, which in front of Nieuport Bains all merge into one.

This is best illustrated by a rough section shown in Fig. 1. In the distance will be seen Olympus, which was a large sand dune standing nearly 100 ft. high, and affording an excellent position for the numerous observation posts which were constructed in it.

The work done in this area can most conveniently be divided into three main headings: (1) Wells; (2) Dug-outs, and (3) Sinking Elephant Shelters.

(1) *Wells.*—These were mostly sunk in the "Brackpan," though we actually put down one well on the seashore and obtained fresh water at about high-water level.

The water level in the "Brackpan" was only 6 in. to a foot below the surface, and as all the ground was running sand, the caisson method, which we adopted, was necessary right from the surface.

The largest size of ready-made caisson which we could obtain was only 4 ft. 6 in. in diameter, and as this was considered to be too small for the requirements we had to resort to making our own. These consisted of a number of circular sets (made like a "Bull Wheel" of a standard drilling rig) studdled apart and lagged externally with corrugated iron; the bottom 18 in., or cutting edge, was strengthened with two iron sets, composed of two angle irons each, bolted together.

The external diameter was 9 ft., and each section was 7 ft. high, and fitted into the one below. (See Fig. 2.)

The method of sinking was by hand excavation, which gradually allowed the whole caisson to sink; to aid this it was weighted internally with wet sand bags, which completely filled the well, with the exception of a small central hole about 2 ft. by 2 ft., extra weight being added by a large heavy superstructure of pit props and sand bags. The sand was hoisted up the central hole in buckets.

Water was very heavy right from the surface, and was at first dealt with by "Dando" hand pumps, but though as many as 24 were working at one time in one well, the water beat them at about 12 ft. and the suction pipes nearly filled the central hole, making hoisting extremely difficult.

Finally electric "Pelepone" pumps were installed, worked from a central generating station, and the wells were sunk to 25 ft., which gave about 20 ft. of water. Below this it was impossible to go, as we only had two pumps available for each shaft, with a capacity of 2,000 gallons per hour each, and at this depth they were only able to contend with the water at low tide, as the well made more than 4,000 gallons per hour when the tide was up, though it was nearly a quarter of a mile from the sea.

When the wells reached this depth a close-boarded bottom of 3-in. timber was put in under the last timber set to prevent the sand from boiling up. Some 15 wells were sunk by this method.

2. *Dug-outs.*—It was only possible to make dug-outs in sand dunes which rose to the height of 30 ft. above high water mark, as 20 ft. of cover was necessary for their safety; the galleries were 6 ft. high, which allowed 4 ft. for undulations in the top of the dune.

Galleries and Inclines.—The standard size of gallery driven was 6 ft. by 2 ft. 6 in., widening out to 4 ft. for chambers, which could not be made wider with safety with the timber available. Though the system employed, piling boards and face boards, is common throughout the world for bad ground, and is probably known to every member of the Institution, a short description may be given to illustrate our method of employing it in this area.

In the first place the sets used were only 4 in., 5 in. and 6 in. wide, but later, as our miners became more skilled in this method of timbering, sets up to 11 in. wide were used in fairly damp sand.

The dunes mostly consisted of perfectly dry silver sand, which would run if left unsupported for one moment; so bad was it in some places that it would run like water from the smallest hole. For instance, on one occasion one of my men was knocked down and buried over his head in less than a minute by a stream of sand issuing from a hole which could have been blocked by a closed fist, could it have been reached in time. As it was he was buried for over an hour and face boards had to be worked back over him before he was freed.

The entrances were driven level into the dunes until 2 ft. or 3 ft. of cover was obtained, then, by inclining the sets in the head and side and top lagging, the level was converted into an incline of 60 deg. dip, which was carried on until the sand became damp, which was usually at about 2 ft. or 3 ft. above water level, then the gallery was driven level once more (Fig. 3), which meant that the bottom of the gallery would be about 6 in. above water level, thus taking advantage of the full height of the dune.

The face boards had to be inserted when part way round this bottom bend, and used from this time forward; the piling boards were put in over the first vertical set (or sometimes earlier), and the cap of the previous set lifted to allow them to pass. After this they were set on a false cap resting at an angle on a pair of legs nailed to the permanent legs and driven forward at a fairly steep angle to allow a cap to be put under them on the legs of the second or third set forward.

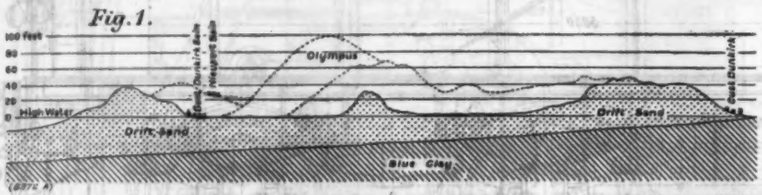
The face boards were worked forward, one at a time, for the width of one set and held in place by "chocks." When the whole face had been advanced in this manner, the sill was laid and a "soldier" was set (consisting of an upright and sprag) to take the weight (see Fig. 4) while the chocks on one side were removed, and the leg quickly inserted, and held in position by wedges between it and the face boards. Then the operation was repeated and the cap put on, if there was sufficient room below the piling boards; if not they were spragged apart with a stretcher. Each shift drove up their own piling boards, which they put in on the previous day, that is to say, some 9 ft. back from the face. For, if each set of piling boards were driven up as they were finished with, the hammering would disturb the face and cause a run. The caps left off to allow the piling boards to pass through were inserted as the latter were driven up out of the way.

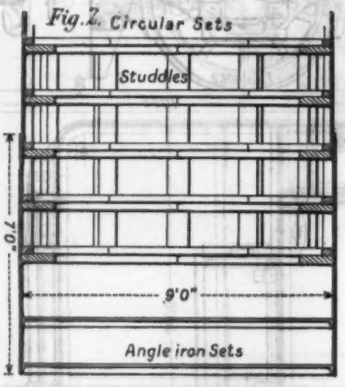
Shafts.—For observation posts it was necessary to sink vertical shafts, to connect with the dug-outs, and as suitable places for observing the enemy were also suitable places to be observed by him, it was impossible to do any surveying by daylight and impracticable by night as no lights could be shown, not so much on account of the risks run by the officer making such a survey, but for fear of giving away the position of the observation post. So we were faced with the problem of how to make a good holing between the bottom of our shaft and the dug-out, as obviously it was impossible to timber from the bottom upwards, as is the usual practice in normal ground.

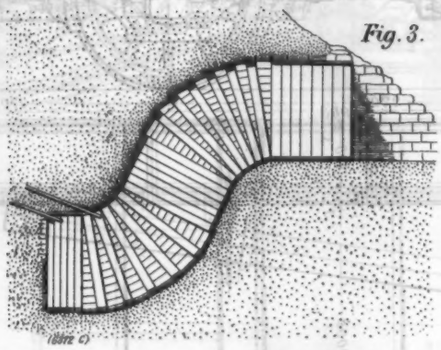
This problem was successfully solved by one of our officers, who drove his gallery to a position which he calculated was underneath where the shaft was required, and then let the roof in at dusk, at the same time assembling timber on the surface for sinking on ordinary pile-shaft, the piles being cut long enough to reach the gallery without an inset.

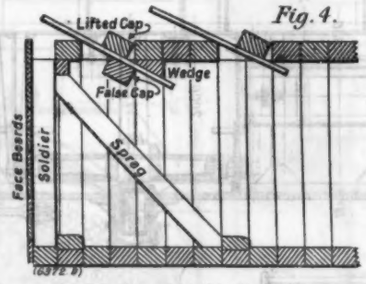
As the fall was cleared away from the gallery, allowing more sand to come in, it ran up to the surface forming a fairly small vertical hole, at first. The first set was laid over this and the piles quickly placed round and pushed down rapidly carrying the set with them. All the spoil was removed through the gallery, allowing full scope for the timbermen in the shaft. By this method shafts were sunk 18 ft. to 20 ft. deep in a night, and no signs were left on the surface of the dune in the morning in the shape of wet sand, timber, &c.

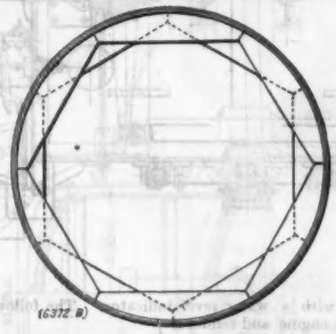
Surveying.—One of our great difficulties was surveying in this part of the line. The only instruments provided

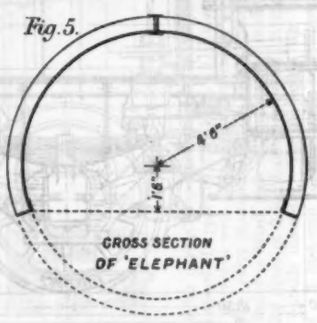


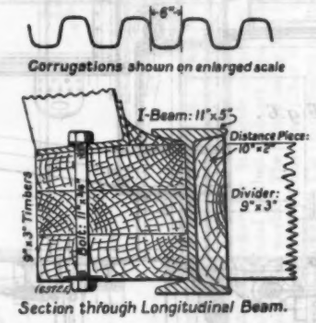












* Paper read before the Institution of Mining and Metallurgy, May 20, 1920.

were a 4-in. prismatic compass and "Abney" level. A number of the holings made were bad in direction, and closed traverses never closed. Sometimes back sights and foresights differed by as much as 20 deg. and seldom checked.

This, we discovered, was due to the enormous amount of iron, in the form of shrapnel, shells, &c., just under the surface of the sand, for when certain winds blew, these were exposed in such quantities, that it is no exaggeration to say that one could not put one's foot to the ground without treading on iron. The greater deflections were usually caused by hidden reserves of ammunition buried a few inches below the level of the sand, to conceal them from German aviators and unwary surveyors.

3. *Sinking Elephant Shelters or Trench Cupolas.*—These were in sections of two-thirds of a circle of 4 ft. 6 in. radius, that is to say, that the centre was situated 18 in. above the chord, which formed its base; they were built up of sections 3 ft. wide (excluding lap) and made of heavy section iron, corrugated into 6-in. channels. Each section was composed of two half-sections with channel irons bolted on to the upper ends and angle irons to the lower.

A full-size elephant was 18 ft. 3 in. long, and this was the size which we usually sunk. In the process of sinking, the pressures to be contended with were almost entirely lateral and end pressures, and to resist these the whole structure was built and bolted down to a strong timber frame, strengthened longitudinally by steel I-beams, studded apart to distribute the lateral pressure, and prevent the whole form bending and breaking its back. The I-beams used were 11 in. by 5 in., and all the timber of the frame was 9 in. by 3 in. (except the distance pieces between the studdles in the web of the I-beam which were 10 in. by 2 in.) as nothing heavier was available. (Detail drawings are shown in Figs. 5 and 6.)

The ground was first excavated to an average depth of 6 ft. to give cover for the erecting gang, then the frame and elephant were built exactly over the spot where they were required.

The sand was then excavated from under the frame from inside, and at first thrown out at both ends, leaving the frame supported on pillars of sand in the corners until last. When the sand had been removed for a foot clear underneath the frame, the four pillars were simultaneously but gradually withdrawn, and the whole structure was allowed to settle down, and then the operation repeated.

When the elephant had been sunk in this manner some 5 ft., one end was completely, and the other partially, lagged up. Usually one end of the elephant was to be connected to a drive, from a dug-out, which had already been driven to within a foot of the final resting place of the elephant, and the other end was to be connected to an inclined entrance, which was to be constructed after the elephant had reached its final depth. (See Fig. 7.)

In this case the following method of lagging was found to save much time and trouble. A set of 5 ft. 9 in. by 2 ft. 6 in. of 6-in. by 3-in. timber was placed on each of the end dividers, and in the last corrugation of the elephant, and vertical lagging set on each side nailed to the end divider at the bottom and held together at the top by diagonal braces nailed to them on the inside, which also kept the sets square. The set on the end to be closed was boarded across horizontally with lighter lagging, lightly nailed in place from the outside, so that they could be knocked out from inside afterwards, and used as face boards.

The two sets were prevented from collapsing inwards by a 9-in. by 3-in. running from the one to the other in the crown of the arch, under which pit props, with their feet on the frame, were set to strengthen the roof, and hold this stretcher in position. (See Fig. 8.)

From then onwards all the sand excavated was taken out to one end only, and as much as possible built on top of the elephant. In order to keep this end open as the elephant sank, Canadian mud scoops, drawn by pairs of mules, were used with considerable success.

Towards the end of the operation the incline became too steep to use these efficiently, and the sand had to be shovelled up from bench to bench.

When the elephant arrived level with the gallery, which was determined by driving an iron rod through the sand between the lagging, the sinking operations ceased and sand was well grouted in under the frame to prevent settlement. The closed end was next opened up and connected with the gallery, and then the incline was built up from the bottom, and mud scoops were again employed with great advantage to replace the sand.

By this or similar methods, varying only in detail, a large number of elephant shelters were sunk in the area to a depth giving from 18 ft. to 25 ft. of cover, and thus overcome the difficulty of chambering in sand.

Fig. 6.

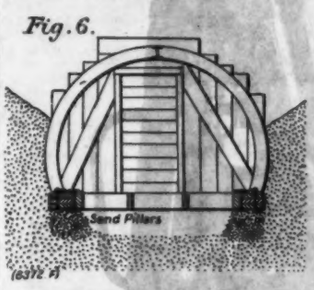
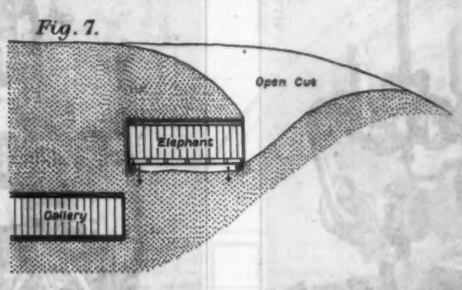
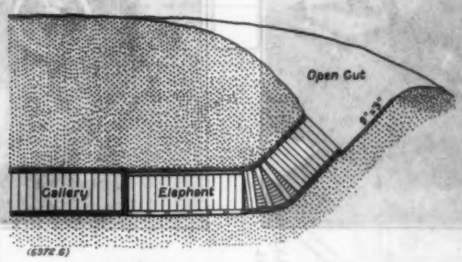


Fig. 7.





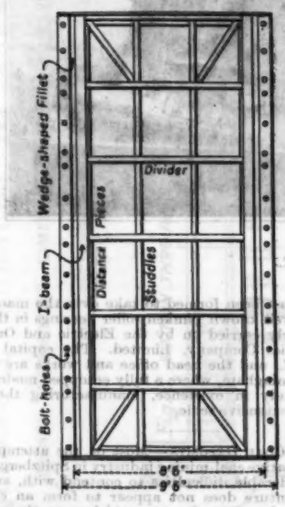
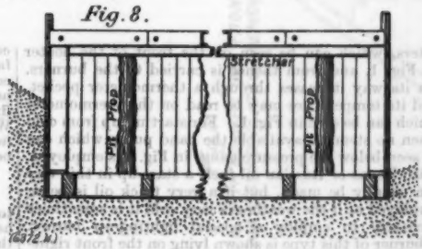


Fig. 8.



Annealing of Electrolytic Iron.—Though the large-scale production of electrolytic iron as a substitute for copper may not long survive the war, it is interesting to see, from a communication presented to the Paris Académie des Sciences by Jean Cournot, in July 19 last, that the annealing of electrolytic iron requires higher temperatures or longer time than is sometimes assumed. Cournot prepared sheets of electrolytic iron, 6 mm. in thickness, and stamped small plates, 3 cm. square, out of this sheet metal. He then heated the specimens to expel the hydrogen which is always present in electrolytic iron and is supposed to make the metal brittle. The annealing temperatures ranged, by steps of 100 deg. C., from 650 deg. up to 1,050 deg. C., and the annealing periods from 10 minutes up to 6 hours. The main test on which he relied was the Brinell hardness test. The original iron had a Brinell hardness of 164. Heating for 10 minutes reduced this hardness to 161, 135, 86, at temperatures of 650 deg., 850 deg., and 1,050 deg. C. respectively. After heating for 1 hour at the same temperatures the hardness went down to 159, 107, 83. The original iron showed a tendency to winning, which Cournot ascribes to the formation of iron hydride. This hydride still existed at 750 deg. C. and did not completely disappear at 850 deg. C. For complete annealing a temperature of 950 deg., maintained for 2 hours, or of 1,050 deg. C., maintained for 1 hour, was required.

"CO-ORDINATION OF TECHNICAL AND SCIENTIFIC PUBLICATIONS."

To the Editor of Engineering.

Sir,—Everyone interested in the remarkable development of industrial research which is taking place in England at the present time will agree that the letter from Mr. Wordingham (see page 80 *ante*) opens up a subject of vast importance in connection with the application of science to industry.

The organiser of a works research department in a country where science is looking for better recognition after centuries of neglect, finds his path obstructed by the most unforeseen difficulties and not the least of these is the question raised in the letter.

The library and information bureau form the very life and soul of any research organisation, and in the laying of foundations for the many new institutions—Government, co-operative, or company—this part of the scheme is calling for the most earnest consideration of the organisers.

Information to be of use must be efficiently filed. The ramifications of knowledge required in connection with the simplest industry to-day form too vast a field for retention in the brain of man. All he can hope to do is to know where to find quickly what he wants when he wants it and in this connection as he is probably the first person to want all the known information in his own particular field, he is faced with the problem of collecting, labelling and pigeon-holing it for daily use.

In most fields of human activity heavy tasks can be split up and duties delegated, but the cleverest director with the most able and painstaking assistants cannot delegate work of this kind. He must maintain an intimate touch with the system in operation or he will find, sooner or later, that he has lived in a fool's paradise, and this is the reason why so many scientific workers will be enthusiastic about Mr. Wordingham's scheme.

I would venture to add a suggestion which might be incorporated in the proposal. Why should we have so many different methods of referring to an article or paper? Personally I have found that all one needs is volume, page and year, and nothing could be simpler than "Eng. ox/80/'20" for the reference to Mr. Wordingham's letter. The exact date or the part of the volume are not often required, though frequently given. Some periodicals show the volume number on every page, and this is very useful to abstractors. Why should not "ox/80/'20" replace "80" at the page number, i.e., if we must have ox instead of 110.

I wish Mr. Wordingham would distribute copies of his letter broadcast among the people who could and should adopt a proposal of such immediate relevance and importance.

I am, yours truly,
P. Dunsheath.

19, Birch-grove, Acton, W. 3, August 4, 1920.

South American Railway Electrification.—We read in *Commercial America* that the Westinghouse Electric International Company, East Pittsburg, Pennsylvania, announces having obtained contracts from the Paulista Railway, Brazil, for four electric locomotives, two for passenger service and two for freight service. The electrified railway will initially be 28 miles in length, but later it is expected to make extensions which will include a distance of 100 miles. The passenger locomotives have a one hour rating of 2,000 h.p., and weigh 121 tons. They will be operated from a 3,000 volt, direct current, overhead trolley system, and will be complete with regenerative control. They are designed for a maximum speed of 65 m.p.h. and have a track gauge of 5 ft. 3 in. The freight locomotives have a one hour rating of 1,500 h.p., and will weigh 87 tons. They are also operated from a 3,000 volt, direct current, overhead trolley system, and will be complete with regenerative control. The maximum speed will be 40 m.p.h., and the gauge also 5 ft. 3 in.

The Chadburn-Empson Salt Detector.—The difficulty and trouble of making repeated tests for the presence of salt in air pump discharge, due to leakage of the circulating water, has resulted in Messrs. Chadburn's (Ship) Telegraph Company, Limited, Bootle, Liverpool, introducing a continuous detector to check this source of annoyance. This device consists of two electrolytic cells, of which the solution in one consists of condensed steam from the main pipe line, and, in the other, of condensate taken from the air pump discharge. The former is called the standard cell, while the latter is the test cell, the standard being arranged as a jacket round the test cell, in order to ensure uniform temperature. With similar quality of liquid in both cells and equal temperatures the two are electrically balanced across a sensitive relay. The presence of salt reduces the resistance in the test cell and as a result of this difference between the two cells an auxiliary circuit is closed and a small electric lamp is lit in front of the instrument, thus giving a continuous comparison. The amount of salt present is ascertained by turning a knob to which is attached a scale, the reading of which can be readily translated into grains per gallon. The movement of the knob is continued until the relay is balanced and the light extinguished. Should the leakage continue and the amount of salt increase the lamp will again be lighted. It is stated that the device is sensitive to the presence of 0·05 per cent. by volume of deep sea water, equivalent to one part of salt by weight in 46,000 parts of water. The test cell is fitted with a drain so that it can be emptied as often as required. The instrument is compact and easily installed. It has the advantage of immediately notifying the passage of salts from the condenser to the boiler. With the usual method of intermittent analysis this may pass unobserved for some time.

SELF-CONTAINED PRESSURE-JET OIL FUEL PLANT.

CONSTRUCTED BY MESSRS. KERMODE'S LIMITED, ENGINEERS, LIVERPOOL.

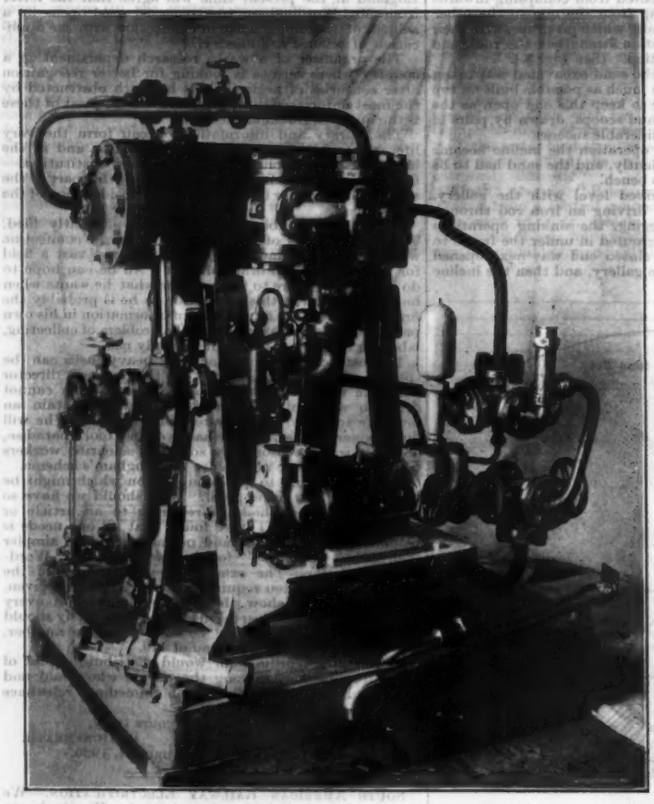


FIG. 1.

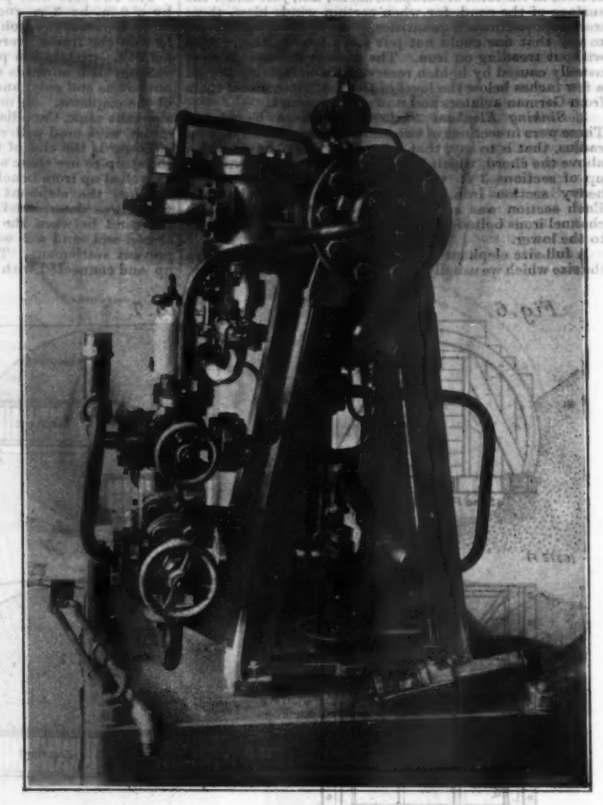


FIG. 2.

An interesting self-contained and semi-portable plant which is manufactured by Messrs. Kermode's, Limited, of 35, The Temple, Dale-street, Liverpool, for use in connection with their pressure-jet system of oil fuel burning, is illustrated in Figs. 1 and 2, above. Plants of this kind have been supplied to some of H.M. oil tankers and to H.M. hospital barges for the Mesopotamia campaign. Various ships of the Anglo-American Oil Company have also been fitted with this type of plant, as has also the electrically-welded ship Fullagar, which was built by Messrs. Cammell Laird, and with which we dealt in some detail in our columns a few weeks ago. The special feature of the plant with which we are now concerned is that the various detail features necessary for supplying the fuel under pressure to the burners are contained in a single unit of which two views are given in Figs. 1 and 2.

Briefly to describe the Kermode pressure-jet oil fuel system, it may be said the oil is atomised in a special burner which uses neither steam nor pressure air, but to which the oil is supplied under pressure. The necessary plant consists of the burners fitted to the boiler furnaces and, in addition, a pump and a heater for supplying the oil in the necessary condition to the burners, together with strainers, valves, &c. A hand-operated starting pump is also employed. All these parts, other than the burners themselves, are incorporated in the self-contained plant illustrated in our figures. The horizontal steam pump which raises the pressure of the oil can best be seen immediately in front of the two main frames of the plant in Fig. 1. This pump draws oil direct from the bunkers through a strainer. It delivers to the horizontal heater which can be seen at the top of the plant. This is supplied with live steam, the steam stop valve being fixed above the heater as shown in the figures. The heater is of the straight-tube type with spiral retarders, the oil passing through the tubes and the steam being on their outside. A water collector for the condensed steam is fitted on the front of the plant and can be seen to the left-hand side of Fig. 1. It is arranged with a gauge glass, and any leakage of oil to the steam space can at once be detected.

The oil from the heater passes to a pair of duplex filters, which can be seen on the front of the heater in Fig. 1, and from thence is carried to the burners. On its way it passes through a thermometer pocket, and its temperature may be read on the thermometer which can be seen in Fig. 1. For starting-up from cold when no steam is available the hand pump which can be seen below the pressure gauge in Fig. 2 is employed. With Texas or Russian oil fuels a start-up in this way can usually be made, but if a very thick oil is being employed or if the weather is very cold it is sometimes necessary to employ a special lighting-up burner. A burner of this type is shown lying on the front right-hand corner of the bedplate of the apparatus in Fig. 1. The burner lying on the left-hand corner, and also shown on the front of the bedplate in Fig. 2, is the working burner.

An example illustrating an application of the burner part of the Kermode pressure-jet oil fuel system is given in Figs. 3 to 7, opposite. These views show an installation carried out for French Navy patrol boats. The boilers are of the water-tube type, each having 3,229 sq. ft. heating surface. The working pressure is 242 lb. per square inch, and the rated evaporation 49,545 lb. per hour. Much higher evaporation has actually been accomplished. The boilers work with open stokeholds and the forced draught is delivered inside the casing carried on the front of the boiler. The arrangement can be seen from the figures. The lay-out of the Kermode burners and air cones is also well shown in the figures. As will best be seen from Fig. 3, the spray of oil is discharged into the furnace through an air cone which consists of an inner and an outer tube. The outer tube is fixed to the boiler casing, but the inner is free to be moved in and out, and acts as a valve to increase or reduce the entrance of air around the oil jet. It is controlled from the stokehold.

PERSONAL.—Messrs. Vickers, Limited, Broadway, London, S.W. 1, inform us that they have opened a depot for Wales and the south-west of England at 43, Park-street, Bristol, at which address they will be glad to receive enquiries for their products.—Under the style and title of British Timken, Limited, a new all-British company has just been formed to take over the manufacture of the well-known Timken roller bearings in this country, formerly carried on by the Electric and Ordnance Accessories Company, Limited. The capital is fixed at 50,000*l.*, and the head office and works are at Ward End, Birmingham, where a fully equipped modern factory is already in existence, manufacturing these bearings on an extensive scale.

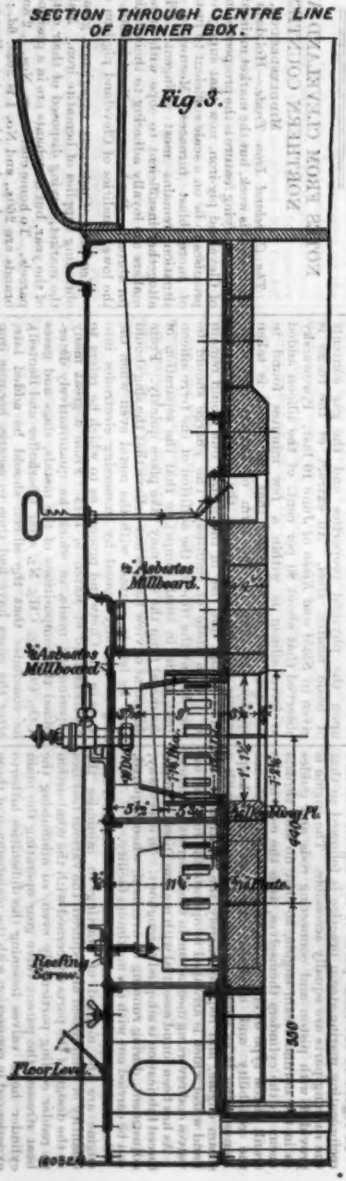
SPITZBERGEN COAL DEPOSITS.—Most of the attempts to initiate a lucrative coal-mining industry in Spitzbergen have had considerable difficulties to contend with, and the Swedish venture does not appear to form an exception to this rule. In order to avoid loss on the undertaking and to prevent foreign capital from securing the control, the Swedish State will be asked to take shares for 5,000,000 kr. in the concern, which is called Spitzbergens Svenska Kolfalt. In the meantime work is being carried on, 160 men being engaged at present, and a further number is expected to proceed to Spitzbergen shortly. The company have at their disposal for the present season four steamers of 2,000 tons to 2,500 tons each, the largest boats which can now be handled there.

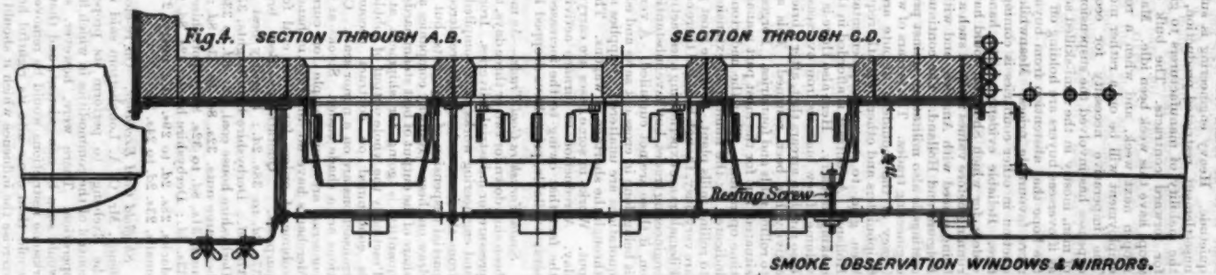
CONTINENTAL AVIATION.—The German Aviation Company, having secured more liberal supplies of motor spirit from America, expects to start a regular mail and passenger service between Berlin and Swinemünde about the middle of July, and on August 1 a route from Warnemünde to Malmö, Sweden, *via* Copenhagen, will be opened. Subject to carrying 100 kg. of mails to and from Berlin every day, the company will receive a subsidy of 5,500,000 marks. Aviation in Denmark is progressing favourably, and the various concession arrangements for the Danish Aviation Company (Dansk luftfartoeselskals) are now understood to have been satisfactorily completed, although official confirmation of this has not yet been received. The first move of importance is the commencement of the Anglo-Danish service, between Copenhagen, Hamburg, Holland and London. The Danish military authorities are handing over the Klövermark site, outside Copenhagen, and also the seaplane station, but will continue to exercise some control over civil aviation. The Northern Air Traffic Company has received permission from the authorities to commence operations at Glostrup, between Copenhagen and Roskilde, and a start has already been made.

APPLICATION OF LIQUID-FUEL BURNING TO FRENCH NAVY PATROL BOATS.

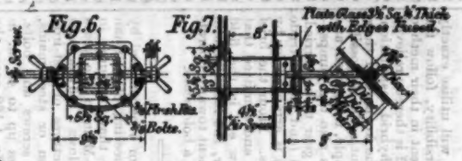
MESSRS. KERMODE'S LIMITED, ENGINEERS, LIVERPOOL.

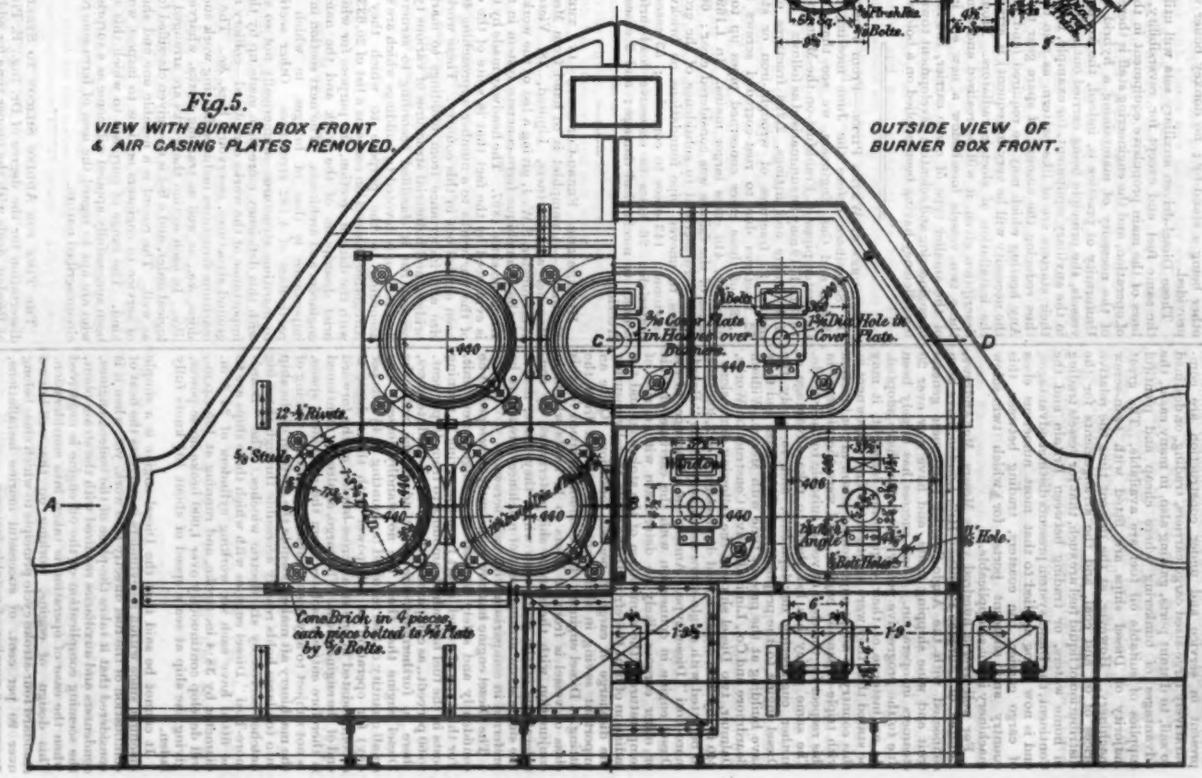
(*For Description see opposite Page.*)





SMOKE OBSERVATION WINDOWS & MIRRORS.





"BEARDMORE" DIESEL SHIPS.

As a method of marine propulsion, the Diesel oil engine is rapidly gaining ground, as the advantages resulting from this system of propulsion become more generally realised. Most, however, of the Diesel ships at present in service and under construction are comparatively large-sized cargo carriers, trading, or destined to sail, to distant ports, gaining also, in many cases, the advantages of bunkering where cheap and plentiful supplies of suitable oil fuel are available. The great majority of Diesel ships are fitted with twin-screw machinery. However, at the present time the relative prices of oil and coal, and the arrangements for the distribution of liquid fuel are such, that for vessels trading in home waters, or trading between Britain and the Continent, the Diesel system presents distinct advantages, and is now being applied to that most numerous class of cargo carrier, the coasters, trading between this country and adjacent ports, for which twin-screw machinery is not so applicable.

For well over a hundred years Messrs. MacAndrews, Limited, of Laurence Pountney Hill, London, have been connected with the Anglo-Spanish-Portuguese general fruit and wine shipping trade, and have now over 20 steamers in operation. Their success has largely been due to the progressive policy which they have adopted. As an instance of their engineering foresight, it may be stated that they were amongst the first shipowners in this country to adopt superheated steam in conjunction with triple-expansion engines, and were the pioneers in this respect for the class of vessel suitable to their trade. The same policy has led them to take advantage of further engineering developments, and to apply the Diesel engine to the propulsion of their ships, and they have building at the present time with Messrs. William Beardmore and Co., Limited, Naval Construction Works, Dalmuir, two Diesel ships of the following dimensions: 340 ft. by 48 ft., with a load displacement of 3,300 tons, to be fitted with single-screw machinery of the "Beardmore-Tosi" Diesel type. Among the advantages of the Diesel engine in connection with the carriage of fruit or other cargoes likely to deteriorate with a rise of temperature is the elimination of the stokehold and the radiation of heat therefrom to the holds, thereby ensuring the discharge of cargo in perfect condition. Quite an important saving in this respect is realised from the fitting of Diesel engines. The economical speed for this class of vessel is from 10 knots to 11 knots which, in conjunction with the size of ship determined by considerations of the ports with which they trade, makes the single screw arrangement of machinery greatly to be preferred in comparison with twin screws.

The Diesel engine has now sufficiently developed to be confidently and safely applied as a single screw unit. For this type of vessel, apart from the saving in running costs in the fuel bill, which amounts to from 40 per cent. to 60 per cent., as compared with coal or oil-fired steamers, there is, furthermore, the great advantage with the Diesel engine that there are no standby losses. The small quantity of fuel required (amounting to 4½ tons per day) for operation at full power with these ships, is accommodated in one small cross-bunker at the forward end of the engine-room. The cargo, as already mentioned is therefore entirely isolated from the machinery space, is not subject to any heat whatsoever, and the placing of the machinery aft makes possible the division of the ship into too large holds readily accessible through three big hatches served by six electric winches. The "Beardmore-Tosi" Diesel engines with which these ships are to be fitted have each six working cylinders of 24·4 in. diameter by 38·4 in. stroke, and running at 105 r.p.m., will develop continuously over 1,000 brake horse-power, giving the ship at sea a speed of about 10½ knots fully laden.

It cannot be said that the Diesel engine is a simple machine, since within its cylinders it converts the heat of combustion of the fuel directly into work, yet, when it is considered that it takes the place of the boilers, engines, condensers and auxiliaries required with the steam plant, the seeming complication of the oil engine is negatived when the ease of operation is taken into consideration. This design of engine, working on the well-known standard four-stroke cycle principle to which class belong over 90 per cent. of successful marine installations, possesses a number of notable features.

In regard to the main parts of the engine, standard reciprocating marine steam practice is followed so that the running parts are equally accessible. The engine is provided with piston and connecting rods and guides as in the normal steam engine, so that no side thrusts occur on the cylinders themselves, as is the case in the trunk piston type of engine. This will largely enhance the reliability and minimise the cost of upkeep. Manœuvring is as simple, if not more so than with a steam engine, and requires merely the rotation of one hand wheel which is arranged to operate the fuel and air valves and reversing mechanism in their correct sequence.

As has been found essential with marine Diesel engines, forced lubrication is adopted throughout. In every way, adjustment, during running or overhaul, when required, can be carried out with the maximum facility.

Some of the special features of the "Beardmore-Tosi" engine are the method of starting to minimise the quantity of compressed air required, the various features in the design of the parts concerned with the combustion to render cooling particularly even, so minimising the heat stresses, the patent valve gear operating the main cylinder head valves lessening the difficulties hitherto experienced in connection with the maintenance of those valves which deal with the exhaust gases from the main combustion cylinder. These are mentioned in passing as some of the features. Quite frequently a considerable portion of the economy gained by the installation of Diesel engines is negatived by the wasteful method of driving auxiliaries through the agency of a steam donkey boiler. With these ships all the auxiliary machinery is driven by electric motors deriving their current from Diesel-driven generators each of 50 kw. capacity installed in the engine-room. For all normal duties one Diesel generator will serve to provide the current required, the other being a stand-by; no donkey boiler whatever is provided.

These Diesel-driven auxiliary sets will utilise exactly the same fuel and except for reversibility, follow the lines of the main propulsive equipment in their method of operation, and the engineering staff is thereby relieved of the necessity of maintaining a hybrid installation. Uniformity of practice is, indeed, the keynote of these vessels, the principle being carried out as far as possible in the auxiliary equipment, for example, the motors and their starters are of like pattern, as also the pumps—thus reducing the amount of spare gear to be carried. Any heating which may be required (and in this trade the necessity will be very infrequent) is arranged for by the installation of electric radiators. From the brief description given, it will be realised and admitted that these two vessels foreshadow a new era in the field of the smaller type of cargo carrier, the latest results of engineering and scientific development towards operating efficiency having been applied on a bold scale.

FAILURES OF WATER PIPES.—From a paper read by Dr. Scheelhase before the June meeting of German Water and Gas Engineers, we see that fractures in the water pipes of Frankfurt-on-the-Main in the years 1898 to 1919 may be summarised as follows: 153 fractures of hydrants and fittings, 2,298 fractures of cast-iron mains, 22 fractures of wrought-iron or steel mains, 62 fractures due to rust-corroded screws and bolts. 1,888 of these cases concerned pipes up to 40 in. in diameter, 410 cases larger mains. In 1,169 cases the cause of the failure was considered clear; 662 of these cases were ascribed to subsidence of the ground; 278 cases to uneven pipe foundations on brickwork, rock or stones; 143 cases to corrosion; 53 cases to faulty materials; 26 cases to excessive road-surface loads; 5 cases to mechanical damage; and 2 cases finally to freezing.

HENNEBIQUE FERRO-CONCRETE IN THE UNITED KINGDOM.—A pamphlet is to hand from Messrs. L. G. Mouchel and Partners, Limited, 38, Victoria-street, Westminster, S.W. 1, giving a list of the works executed on the Hennebique ferro-concrete system in the United Kingdom since 1897. The headway made by this system is evidenced by the fact that in spite of the dislocation of the war works to a number approaching 40,000 have been carried out in this country. These works range in size and importance from buildings to marine works, bridges, and industrial structures of various types. The present list is classified according to structures. The first section is devoted to buildings which are subdivided according to the purpose to which they are put. Altogether this section contains a list of 20,633 buildings, with the date of erection, the purpose for which built, a brief description of the work and the names of the engineers and architects. The next section in numerical importance is that of bridges, in which are given particulars of 4,182 structures. Other sections relate to maritime structures—numerically not so strong, but with this deficiency more than made up by the size and importance of the works completed—colliery and underground structures, reservoirs, bins, &c. The section on maritime structures includes floating work such as tugs, ships, &c., as well as training works, wharves, and the like. In each section the works are arranged in chronological order, and a list is also given classified for counties as well. The record is a notable one and should prove of service to engineers anxious to inspect works of the kind. The range of purposes to which this system has been successfully applied will come as a surprise to many who are apt to regard the uses of ferro-concrete as of a circumscribed nature.

THE TIME FOR ADDING SILICON TO STEEL.—In his dissertation for the degree of Dr. Ing., E. Piwowarsky, of Breslau, deals with the proper time for adding silicon to the steel in the ladle and the influence of this time upon the physical properties and the gas contents of basic molten steel. An extract of the thesis is given in *Stahl und Eisen* of June 10 last. Piwowarsky observed that about 80 per cent. of the silicon added as ferro silicon is within a few minutes found in the slag, and he maintains that the silicon is taken up by the slag in the form of ferrous and manganous silicates, and not in the form of silica; the latter would not rise in the metal, but would remain in it in a state of emulsion. The charge should be very hot at the time of the addition of the ferro silicon (best made in small lumps), so that the separation of the metal from the slag may take place quickly. From this point of view he does not believe that the slag should long be left in contact with the metal even when the slag is specially heated by immersing electrodes into it, as in the Chetwynd process, as to which he refers to ENGINEERING of March 5, 1915. From a great many experiments made, in which he quantitatively determined the compositions of the metals, slags and gases (CO_2, CO, H_2, CH_4, N_2, after Oberhoffer and Beutell), he concludes that the silicon should be added late, after the gases have had time to escape, because iron containing even very little silicon retains the gases much more persistently than when free of silicon. Malleability and rolling tests are also mentioned in this suggestive review of work. The research refers to the need of economising silicon during the war.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The state of the staple trades shows a good deal of variation. Sustained activity on a wide scale is to be found side by side with unquestionable quietude. Heavy engineering is suffering from labour unsettlement, restricted production, inflated prices, and the inability of manufacturers to give firm quotations for forward contracts. The bulk of the engineering shops have this week been idle. Many of them will not reopen next week, and when a resumption is made, employment will be on a rather more restricted basis. The imperative necessity for economy in working expenses has involved the suspension of some hundreds of men, mostly in the semi-skilled sections. It appears as if overseas buyers are holding off the local market in the hope that abstention from buying will bring about more favourable prices. Meanwhile, competitive production in other countries is coming once more to the fore. Reliable evidence is to hand that substantial orders, for which Sheffield would have been well in the running before values reached such a record altitude, are being placed with America, and with manufacturers in Belgium and Holland. The continued scarcity of large castings is also militating against progress in the heavy engineering trades. The arrears of work which formed a legacy of the moulders' dispute are still in evidence. Shipbuilders and others urgently requiring delivery have been glad to accept supplementary contracts from Holland. A contrast is afforded in the case of the steel-making industry. Here also there is a diminution in the volume of new business from overseas buyers, but output is so much in arrears that, after a brief respite, maximum activity has been resumed. This applies particularly to rolling mills and foundries. Forges are less favourably situated, but for the most part manage to maintain full-time operations. That the undertone is fairly sound, is indicated by the number of extensions now in progress to rolling mills plant. For the most part the tool trades are very busy, though here and there conditions are easier. Filemakers are experiencing a less active demand from the engineering trades, but have substantial contracts to work on, if these are not curtailed. A very healthy business is being done in cross-cut saws and edge tools. Pig-iron quotations are unaltered. Supplies are being held back through the shortage of wagons. This is retarding output. Works in some cases are carrying on from day-to-day. A reduction in furnace activity is indicated by the fact that owing to the increased quantity of steel scrap available, prices have dropped 1*l.* per ton.

South Yorkshire Coal Trade.—As most of the pits have been shut down for two or three days, there is an increased pressure for industrial deliveries. Iron and steel concerns and engineering works have compiled substantial stocks from the increased tonnage rendered available by the partial suspension of shipments, but are anxious not to draw on these. Railway companies are taking the lion's share of the output of best steam hards; a strictly limited quantity is going for shipment at favourable rates. Practically the whole output of cobbles, nuts, and slacks is condemned on contract account. Open-market transactions are on a minor scale. Cokes of all descriptions are a shade easier. Stocks at electricity and gas concerns are quite ample for current requirements. Merchants have no difficulty in handling the increased volume of orders for house coal for winter stocking purposes. Quotations:—Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best Silkstone, 37*s.* 2*d.* 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

Sheffield Coal Exchange.—On re-election to the Presidency, Mr. C. A. Longbottom said it was difficult for the Exchange to perform its proper functions while control of the commodities in which it dealt remained in operation. There were, however, signs that control would soon be non-existent, and that its irritating and irksome restrictions would be removed. The Exchange would then come into its rightful heritage, and would exercise the influence which it should do in a centre like Sheffield.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Holidays have checked business this week, but the market maintains its firmness, and a gratifying feature is the prospect of increased output of Cleveland pig-iron, now that supply of raw material promises to be on a scale sufficient to justify the starting of more blast furnaces. Meanwhile, however, the situation remains most stringent. With production altogether insufficient to cope with home requirements makers are loyally adhering to their decision not to sell for abroad. For home use, No. 1 is 230*s.* and No. 3 and the lower qualities of Cleveland pig-iron are 217*s.* 6*d.*

Hematite.—Customers experience great difficulty in obtaining supplies of hematite iron. Makers are not in the market, having disposed of their output to the end of the year, but merchants are in a position to offer small parcels. To home customers, Nos. 1, 2 and 3 East Coast brands are 260*s.*, and No. 1 is 262*s.* 6*d.*; and the minimum quotations for shipment to France, Belgium and Italy are 265*s.* for mixed Nos. and 267*s.* 6*d.* for No. 1, business having been put through at rather higher rates.

Coke.—Demand for coke is heavy. Average blast-furnace kind is selling at 62*s.* 9*d.* at the ovens; and

quality low in phosphorus at 65*s.* 3*d.* at the ovens. For export gas coke is quoted 230*s.* and upward.

Foreign Ore.—There is very little passing in foreign ore, sellers still failing to tempt consumers into the market. Best rubio is round about 52*s.* c.i.f. Tees.

Manufactured Iron and Steel.—Finished iron and steel manufacturers have a lot of work on hand, and they report continued good home inquiry, but foreign business is very quiet just now. Principal market quotations stand:—Common iron bars, 30*l.*; marked bars, 32*l.*; iron angles, 30*l.* 15*s.*; rivets, 38*l.*; steel ship, bridge and tank plates, 23*l.* 10*s.*; steel angles, 23*l.*; boiler plates, 30*l.*; steel joists, 23*l.*; channels and flats, 23*l.* 5*s.*; rounds and squares, 25*l.* 10*s.*; soft steel billets, 25*l.* 10*s.*; hard steel billets, 26*l.* 10*s.*; heavy steel rails, 25*l.*; and fish plates, 30*l.*

Ironworkers' Wages.—The accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England have certified the average net selling price of iron bars and angles for the two months ending June 30 last, at 28*l.* 8*s.* 0·24*d.* per ton, as compared with 25*l.* 8*s.* 0·49*d.* per ton for the previous two months. On these figures the sliding scale gives an advance of 30 per cent. on puddling and other forge and mill wages, to take effect from the 2nd inst.

Iron and Steel Shipments.—Returns for July give the shipments of iron and steel from the port of Middlesbrough during that month at 89,909 tons, 43,630 tons being pig-iron, 4,538 tons manufactured iron, and 41,741 tons steel. Of the pig-iron despatched, 25,312 tons went abroad, and 18,318 tons went coastwise, the principal receivers being: Scotland, 13,928 tons; Belgium, 9,653 tons; Italy, 5,650 tons; France, 3,462 tons; the Tyne, 3,280 tons; and the United States of America, 2,250 tons. Of the manufactured iron loaded, 4,276 tons went to foreign destinations, and 262 tons went coastwise, India with an import of 2,436 tons being much the largest purchaser. Of the steel cleared 37,347 tons went to foreign ports, and 4,394 tons went coastwise, the heaviest customers being: India, 13,860 tons; Portuguese East Africa, 5,940 tons; Egypt, 4,576 tons; the Argentine, 2,234 tons; and Japan, 2,057 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Markets.—Holiday conditions have pervaded the coal markets during the past week. The official holidays of the miners extended from Monday till to-day, and it is not expected that a full restart will be made to-morrow. The coal trimmers and tippers at the docks also for the first time had three days off, so that it was practically impossible for operators to do much business on the coal market. Supplies of coal of all grades for export remained exceedingly scarce, for the quantity available for shipment, after collieries had met a proportion of their contract commitments, was practically negligible, notwithstanding that the weekly quantity, amounting to about 60,000 tons, taken by the railways, was diverted to export. The whole of this 60,000 tons was, however, allocated to Italy and Greece, and would be absorbed in clearing off arrears in contract commitments so that this concession did not increase the amount of free coal available on the market. Exports for the week ended Friday last from South Wales to foreign destinations totalled 264,663 tons, or over 2,000 tons less than in the preceding week, and nearly 30,000 tons less than in the week ended July 16. Of last week's shipments 160,924 tons went to France, 16,109 tons to Italy, 3,944 tons to South America, 6,226 tons to Spain, 13,850 tons to British coaling stations and 6,454 tons to other countries.

The Decrease in Coal Exports.—Official returns recently issued of cargo and bunker exports, foreign and coastwise, shew that in the first six months of this year the reduction in these shipments of about 24,000,000 tons, as compared with the first half of 1913, approximately corresponds with the reduction in output in the United Kingdom for the same two periods. On the other hand, the quantity supplied to home industries and some consumers in the first half of this year was about 1,000,000 tons more than in the first six months of 1913, so that it is clear that the foreign export trade of the country has had to bear the whole of the sacrifice consequent on the reduction in outputs. On Sunday last conferences of South Wales transport workers, railwaymen, coal trimmers and tippers were held at Cardiff to consider the question of notices served to about 500 Cardiff Railway Company employees as a result of the diminished trade of the port, principally consequent on the limitation of coal exports. It was decided that if the notices become operative on Monday next a meeting is to be convened for the following Sunday to decide on future action and with a view to an immediate withdrawal of labour. A resolution was also passed by the Cardiff City Council during the week urging the Coal Controller to inquire into the cause of reduced coal output and to take steps to increase same.

The Iron and Steel Trades.—Tin-platers and steel workers are holiday-making this week, and consequently business is practically at a standstill. The outlook, however, is none too bright for there is a lack of buying orders. Works generally are pretty well booked up with contract orders, but middlemen in many cases are ready to do business at about 2*s.* per box under manufacturers' prices in order to get rid of contract stocks. For the standard box 61*s.* is indicated. In the scrap-iron market heavy steel is quoted at 10*l.* 5*s.* to 10*l.* 10*s.*, steel scrap shearings 9*l.* 10*s.* to 10*l.*, and inferior qualities 8*l.* to 8*l.* 10*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—With all the steel works once again in full swing steady running is now looked forward to for the next few months, as order books are all well filled up. In some establishments there has been a large amount of repair work going on during the past fortnight, and with plants now thoroughly overhauled and in good working order large outputs are expected. Managements are alive to the fact that every possible ton must be secured and no efforts are being spared in this direction. High prices continue to rule, and although much has been said about the possibility of a fall it has been mostly on the part of those desirous of that change taking place. A shading of quotations may be agreed upon by the Scotch steelmakers, but it is doubtful if anything will be done meantime in view of the promised advance in railway rates for goods traffic. The whole question is under consideration. If the railway charges are substantially increased nearly everything will in consequence become dearer, and how can prices be reduced if oncost gets much higher than it is at present. New business at the moment is very slow, and buyers are not placing much more than they can help. The demand for deliveries of all classes of material ex-contract is heavy, as work throughout the country is still plentiful and most industries are busy. The makers of black sheets are being very much pressed for stuff and for the galvanised article there is a good outlet. Export business is dull all round.

Malleable Iron Trade.—Active conditions continue to rule in the malleable iron trade of the West of Scotland, and consumers are always anxiously awaiting deliveries. The works are now in full operation and a heavy tonnage is being turned out, but large as it is it does not seem large enough to cover the demands of buyers. Order books are well filled on home account, and a little business is going through in export. Prices are steady, and no alteration is expected until some decision is come to with regard to the raising of the railway rates a month hence.

Scotch Pig-Iron Trade.—No change has taken place in the Scotch pig-iron trade over the week and supplies are as difficult to obtain as ever. The demand is much greater than the supply, which is not nearly enough to go round. Both No. 1 foundry iron and hematite are still extremely scarce, and every endeavour is being put forth to increase the output, but all efforts to meet the growing demands of consumers seem to be of little avail. The arrivals of foreign ore are not as satisfactory as they might be and the shortage there does not help matters. Prices continue very firm.

Scotch Shipbuilding.—The Scotch shipbuilding returns for the past month form very interesting reading, but whereas there has been little doing in the North, the two main rivers, the Clyde and the Forth, have been particularly active in the matter of new tonnage. The figures are as follow:—

	Vessels.	Tons.
The Clyde	22	65,316
The Forth	4	10,520
The Tay	—	—
The Dee and Moray Firth	1	90
	27	75,926

The above total is considerably higher than the average month of the year to date, and when it is remembered that all the yards were off for from 10 days to a fortnight for the annual holidays the figures are exceedingly satisfactory. The Clyde output is decidedly so, and despite the many difficulties which have had to be contended with in regard to securing deliveries of steel and other materials, the total for the month is now the second highest for this year. The monthly average has been bettered and the year's total output to date is now 115 vessels of 352,262 tons, which ranks fourth in the list of vessels launched. It is 56,000 tons ahead of the total at this time last year, and is but 25,000 tons less than the total for the corresponding period of 1913, when the figures amounted to 146 vessels of 377,270 gross tonnage. In the remaining five months of this year there is no holiday break, and it would not be at all surprising if at the end of that period the year's total created a new record. There is plenty of work on hand and there is no scarcity of labour, the only real difficulty being the shortage of materials. For steel plates, &c., the outlook is now somewhat better owing to the majority, if not all of the principal shipbuilding firms having an interest in one or other of the steel producing companies. Of course, there are other things required besides steel, and some of these are still very difficult to obtain. Fresh contracts have been conspicuous by their absence during the month, but without any additions to the orders already booked most of the yards can carry on for quite a long time yet. Prices will have to ease considerably, however, before there is likely to be any great rush of new business, but as everything is so dependent on wages much of an easing off in quotations cannot be looked for yet awhile.

THE AUTOMOBILE ASSOCIATION AND MOTOR UNION.—The fifteenth annual meeting of members of the Automobile Association and Motor Union was held at the Savoy Hotel on July 28. Sir William Joynson-Hicks, Bart., M.P., the chairman of the association, presided. In moving the adoption of the annual report, Sir William Joynson-Hicks said that this time last year their membership was 60,552. They passed the 100,000 figure on February 6 of this year; the membership to-day was only one or two short of 140,000 members. One week recently they added 2,666 new members to their roll.

NOTICE OF MEETING.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, August 7, at 2 p.m., in the Wood Memorial Hall, Newcastle-on-Tyne, the Annual General Meeting will be held. The following papers will be open for discussion: "Stone-Dusting in Collieries," by Mr. L. G. Hill, F.R.S.A., M.S.W.I.E. [Trans. Inst. M.E., vol. lix, pages 173 and 250]; "A Few Notes on Coal-Dust Experiments," by Mr. R. W. Anderson, M.C., B.Sc. [Trans. Inst. M.E., vol. lix, page 256]. The following paper will be read or taken as read: "The Electric Welding of a Corroded Boiler Shell," by Mr. A. K. Dawson. An electric arc welding plant will be exhibited, described and demonstrated by the United Arc Welding Company, Limited, South Shields.

THE OIL-BURNING STEAMSHIP "ORITA."—The Pacific Steam Navigation Company's liner Orita has resumed service after being provided with oil fuel apparatus. The system used is one of the Smith Dock Company's pressure "jet" systems, and the whole of the work of converting the three double-ended and three single-ended boilers for oil-burning under natural conditions has been carried out at Birkenhead by Messrs. Cammell Laird and Co., Limited. An extensive system of steam heating has been fitted in the fuel storage tanks. Pneumercator gauges for registering the amount of oil in the storage tanks have been fitted, and the installation otherwise embodies all the latest improvements. The provisions for fire extinction throughout the machinery spaces are elaborate and comply with the latest requirements of the Board of Trade. On completion of her reconditioning the Orita carried out a very satisfactory trial trip in Liverpool Bay, the oil-burning installation giving complete satisfaction. Messrs. Cammell Laird have considerable experience in the installation of oil fuel apparatus, having constructed one of the earliest British oil-driven destroyers. They were also pioneers in the conversion of merchant steamers to oil burning. They have now in hand over a dozen vessels for conversion to oil burning.

THE PRACTICAL VALUE OF FUELS.—In a note contributed to the Paris *Academie des Sciences*, M. Emilio Donnour observes that the practical value of fuel is far from completely determined by the calorimeter. This gives indeed the total quantity of heat energy available, but tells nothing as to what proportion of this can be usefully recovered. He has accordingly determined the efficiency factor for different fuels employed in different ways, his results being as follows:—

Type of Fuel.

Type of Furnace.	Cardiff Coal.	Coke-Oven Gas.		Blast-Furnace Gas.		Tar.	
	Efficiency.	Efficiency.	Relative Value.	Efficiency.	Relative Value.	Efficiency.	Relative Value.
Boilers ..	80·1	89·6	1.11	84.7	1·05	90·0	1·12
Reheating furnaces ..	46·1	71·4	1.54	57.7	1·25	73·1	1·5
Steel furnaces ..	57.8	63·4	1·10	68.1	1.18	71·7	1·24
Cowper plant	—	85·3	1·09	78.3	1.00	86·1	1·10

BOY MECHANICS (R.A.F.).—The Air Ministry announce, under a new scheme which has been established for training boy mechanics in the Royal Air Force, that an open competitive examination for candidates for entry in January, 1921, will be held by the Civil Service Commissioners on Monday, November 1, at the undermentioned centres: Exeter, Southampton, London, Bristol, Cardiff, Birmingham, Norwich, Manchester, Leeds, Hull, Newcastle, Glasgow, Edinburgh, Aberdeen, Dublin, Belfast. The examination will include mathematics, experimental science, English composition and a general paper. There will be a minimum of 300 vacancies. Candidates must be the sons of British-born parents and must be between the ages of 15 and 16½ years on January 1, 1921. The necessary entry forms can be obtained on application to the Secretary, Civil Service Commission, Burlington House, London, W. 1, after August 2. The last day on which applications can be accepted is Thursday, September 2. Boy mechanics, Royal Air Force, are attested for twelve years' service from date of entry, made up by ten years' regular Air Force service and two years in the Reserve. They receive three years' preliminary training in one of the skilled Air Force trades, which include those of carpenter, coppersmith, draughtsman, electrician, fitter, instrument-maker, turner and machinist, wireless operator mechanic. Throughout the three years' training, 8 hours a week are devoted to an educational course which will include English (language, literature, history, geography and civics), practical mathematics, general science and drawing. Special attention is given also to boys' physical development, nine hours a week being allotted to drill, physical training and organised games. The health and general welfare of the boys are given careful and general supervision during their period of training. Boy mechanics will be provided with a free outfit, will be lodged and victualled free of cost and will receive pay at the rate of 1*s.* 6*d.* a day until the age of 18, when the rate becomes 3*s.* a day.

THE BAGHDAD RAILWAY.

(*For Description, see Page 174.*)

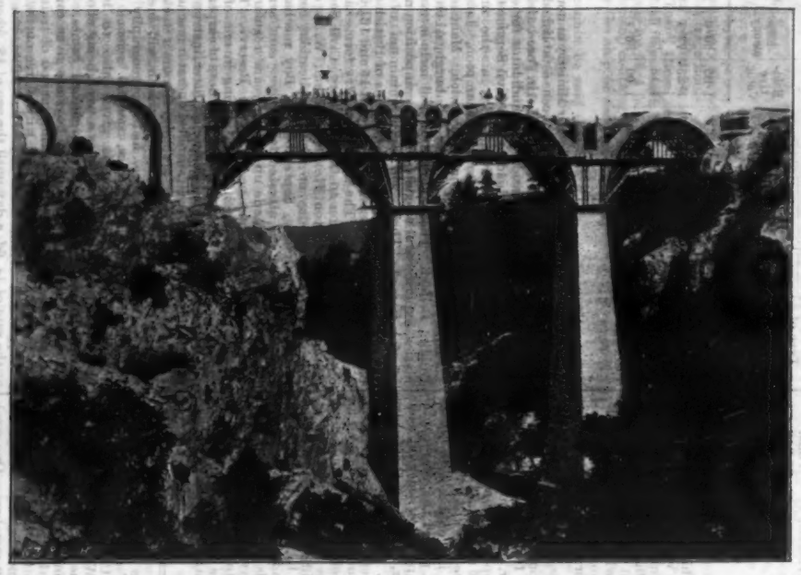


Fig. 5. Hadji-Kiri Viaduct under Construction.

Fig. 6. Typical Connecting Bridge; Taurus Tunnel Section.

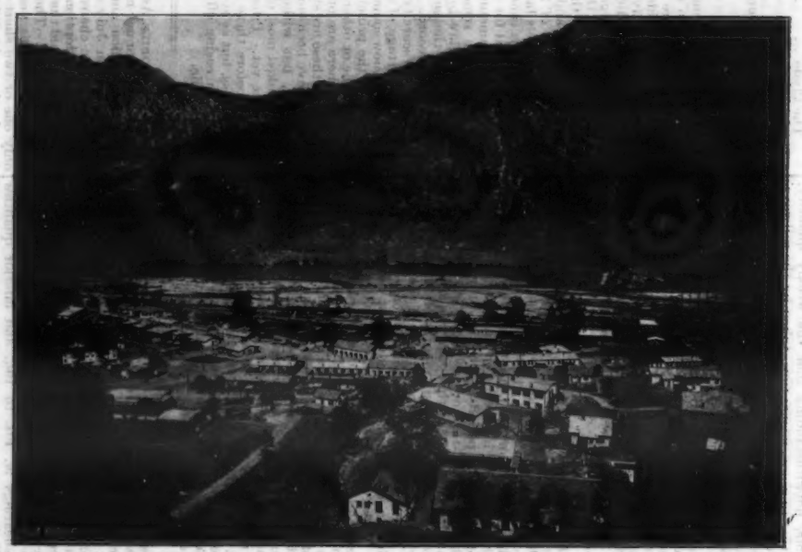


Fig. 7. Belemedik Construction Camp; Taurus Tunnel Section.

Fig. 8. Ten Span Bridge over the Euphrates at Jerablus.

2-8-0 TYPE SUPERHEATER LOCOMOTIVE FO

CONSTRUCTED BY THE SWISS LOCOMOTIVE WORKS

(For Description, see Page

Fig. 1.

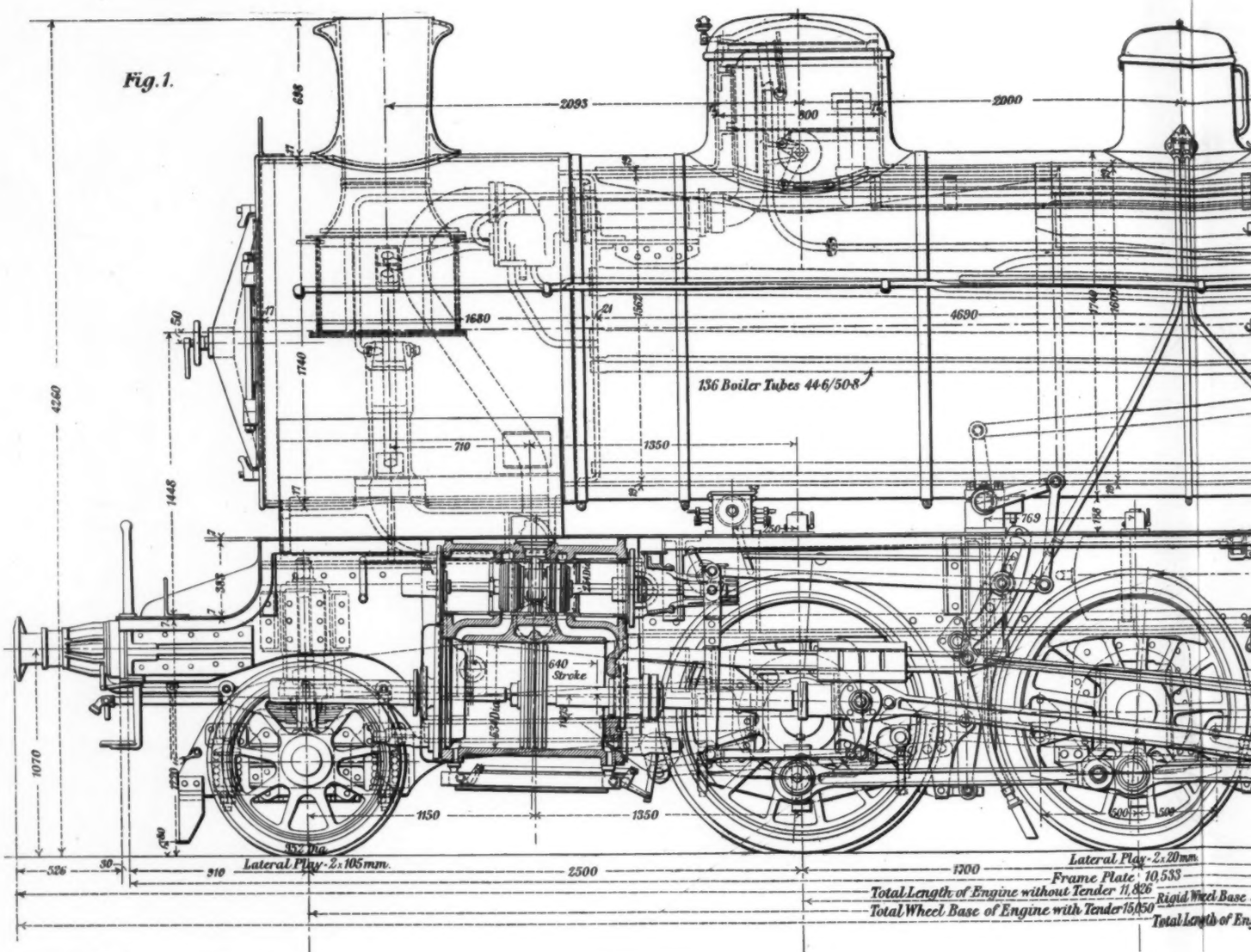
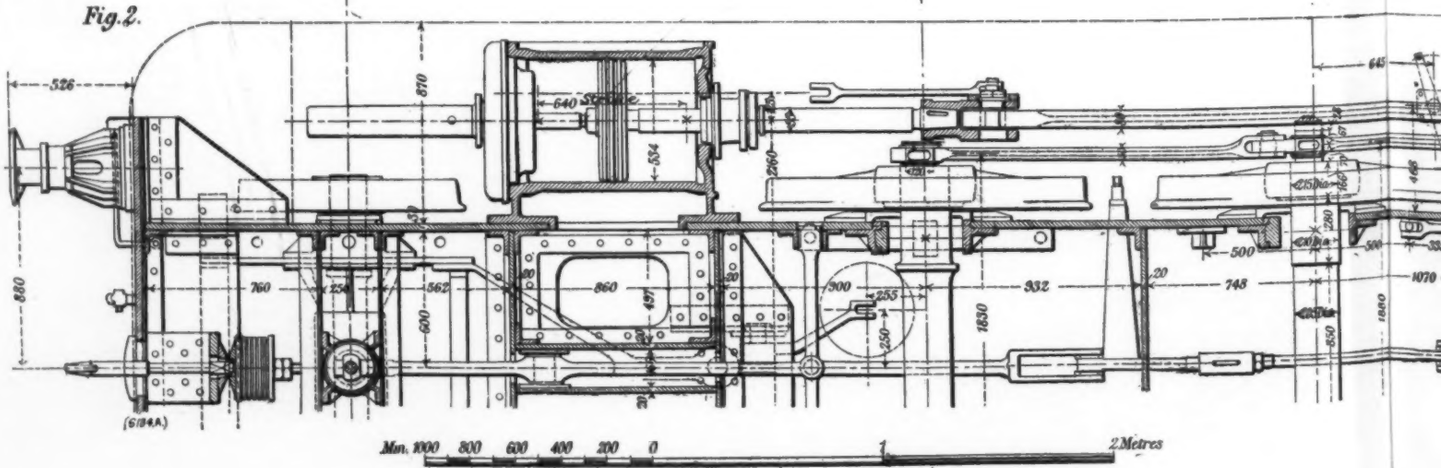


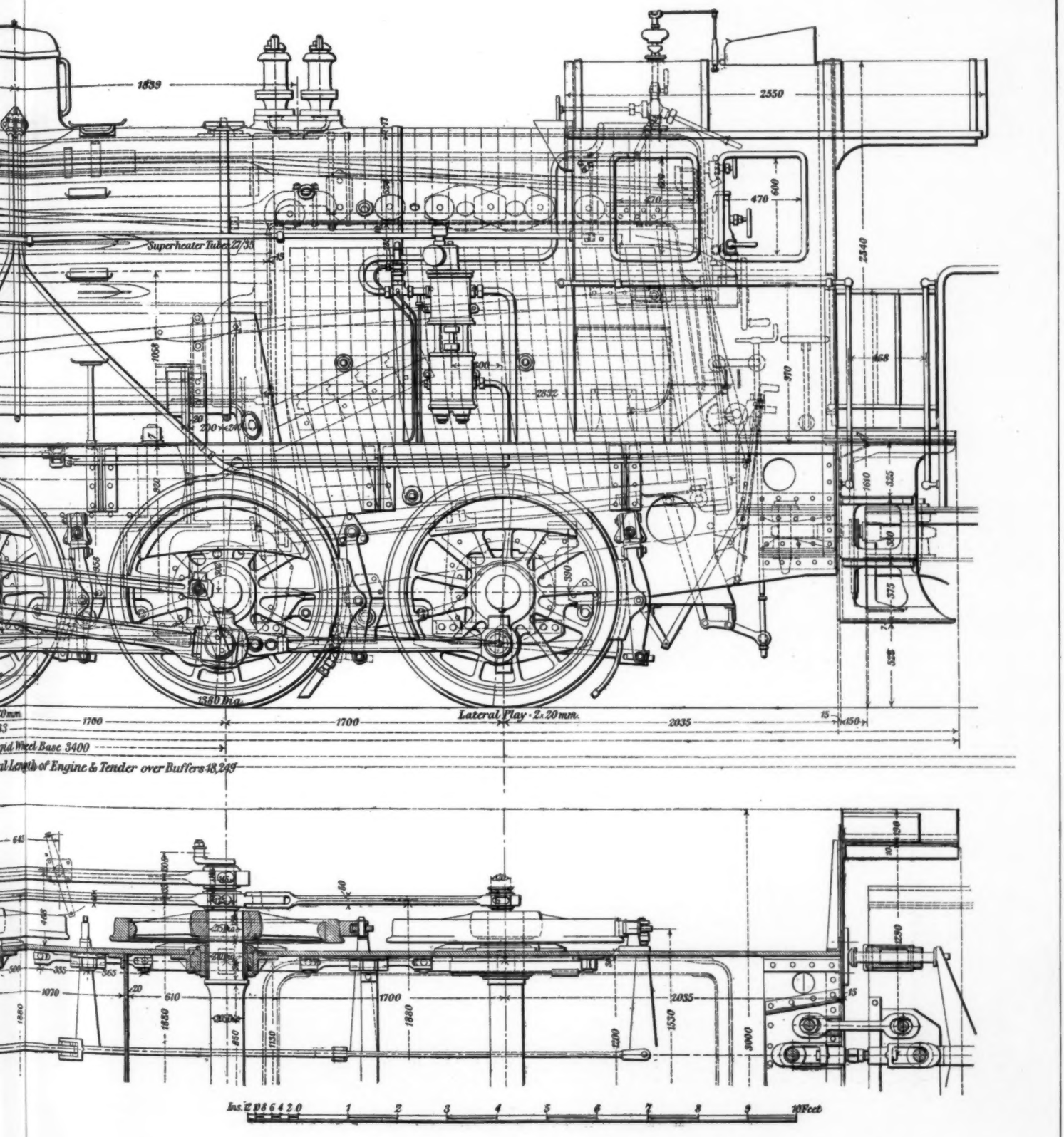
Fig. 2.



IVE FOR THE MINISTRY OF MUNITIONS.

HOTIVE WORKS, WINTERTHUR, SWITZERLAND.

iption, see Page 176.)



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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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For Canada—	
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Thick ,, ,,	£3 3 0
For all other places abroad—	
Thin paper copies	£3 3 0
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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With a Two-Page Plate of a 2-8-0 TYPE SUPERHEATER LOCOMOTIVE FOR THE MINISTRY OF MUNITIONS.

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. So long as postal rates remain as at present there will be no increase in the price of copies sent by inland post, which will continue at 1s. 2d. post free.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 183.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

ENGINEERING.

FRIDAY, AUGUST 6, 1920.

DEFECTS IN DROP-FORGINGS.

DROP-FORGING and stamping is a branch of engineering work which expanded to a very considerable extent during the war. As a result many works managers and other engineers found themselves in a position in which they were not only able, but were compelled, to obtain experience in what was to them quite a new branch of work. To a very large extent these experiences, we imagine, suggested that there was more in drop stamping than many of them had supposed. The broad lines of the matter were commonplace to every shop man, but when he came to put the broad lines into practice he frequently found quite unexpected things happening. In the end he mostly won through (and very much good work was done by people new to the job), but he might have won through earlier if a little detail information in reference to the particular articles on which he was engaged had been available. Drop stamping, like swimming, cannot be taught on paper, but some assistance might, for instance, have been furnished from the *Ministry of Munitions Journal*. It was not, however. That publication was not distinguished for its helpfulness to the man in the shop, who was really turning out the material for which the Ministry placed the orders.

Although, as we say above, drop-stamping cannot be taught on paper, any more than any other shop process can, considerable help can be given and an excellent illustration of the form that that help can take was furnished by a paper recently read before the Association of Drop Forgers and Stampers at Birmingham by Mr. P. Rowley. The paper was entitled "Some Troubles of a Drop Forger," and dealt with some of the causes which most frequently lead to defective drop-forgings. Mr. Rowley reviewed the causes under three heads dividing them up respectively into those due to defects present in the steel, those due to defects of design in the parts to be forged, and those due to the mismanagement of the drop-forger. Of these causes probably the first two are relatively the more important. Given suitable material, a rational design of forging to be produced and proper die blocks, a skilled drop-forger is not likely to go far wrong. Apart from the burning of his material, there is little in which he can go wrong, although an inexperienced man may certainly destroy the die-blocks by unskilful handling.

That rejected drop forgings may owe their rejection to defects in the steel from which they are made is a matter on which there have been "conversations" between steel makers and drop forgers No doubt in the failures of this world there is frequently a tendency to blame the other party to the transaction, and without championing either side one must admit that in the case of a fair proportion of failures the steel has been to blame. As Mr. Rowley pointed out, if a billet has a crack, or a lap, which is oxidised inside, the most skilful drop stamper in the Midlands cannot eliminate it by any process during forging. If there is a crack there is a fair chance that so far from disappearing it will extend during working especially if the metal is spread by a peg in the die. Another matter which may be very serious is that cracks which do not open out during forging may, and very probably will, extend further during the oil and water quenching which may accompany the heat treatment of the finished forging. Small surface cracks are not desirable in billets, but as was pointed out in the paper they may frequently be got rid of by a careful forger turning the work over in the die so that the cracked metal tends to run into the flash.

Other defects in billets, which will not be unfamiliar to the very many shop men who had to deal with the manufacture of shells during the war, are piping and ghost lines. In the case of some drop forgings piping, if present, will be bored out of the finished article, but if bad, it will not assist the machining. Its effect may, however, be more serious than spoiling drills, and a case was quoted of a propeller boss which on quenching split throughout its entire length due to the effect of bad piping and the uneven forces set up on contraction. Ghost lines in moderation are perhaps less serious than piping, but they may certainly lead to the rejection of finished machined drop forging. They are due to segregates in the steel; manganese sulphide and silicates are suggested by Mr. Rowley. They are formed in the ingot in blow holes and drawn out in the rolling. A somewhat different form of segregation may be due to improper mixing of the constituents of an alloy steel.

A particularly interesting example of a 3 per cent. nickel chrome steel was quoted in the paper. This was worked up into connecting rods, the forgings being brinelled each in three places and passed as satisfactory, and yet when they reached the machine shop complaints were received about them being too hard. Examination showed that in all cases boring had been carried out to some depth before the hard patches were encountered. A rod was then cut through the centre longitudinally and polished, when it became evident that the steel had a hard central core. Analysis showed that the outer layer had a carbon content of 0·37 per cent., while the inner part approximated to 1·0 per cent. The segregation of carbon was due to the method adopted by the steel maker to prevent piping. The ingots were cast in moulds fitted with a feeder head and on the surface of the molten metal a layer of charcoal was placed and kept aglow by an air-blast. This kept the metal at the top of the mould in a molten condition and allowed it to sink down as contraction took place. The fused slag should have prevented contact between the carbon and steel, but evidently the steel, which solidified round the sides of the feeder head, became carbonised and was then melted by the heat of the burning charcoal. This penetrated the slag, and the ingot became impregnated with a pipe of high carbon steel.

Mr. Rowley mentioned another case of segregation. It concerned a consignment of 5 per cent. nickel case-hardening steel. A number of gear blanks were forged from the steel and were found to develop serious cracks. They were then rough machined to see if it would be possible to remove the cracks without scrapping the forgings, and in every case bright patches of metal became evident, the cracks extending along the borders of the patches. On analysing chippings from these bright areas they were found to be very high in nickel content, some chippings showing as much as 20 per cent. nickel. The parts could not possibly have been used as the cracks would have extended in carbonising operations, and the example was clearly a bad case of insufficient mixing before pouring. Mr. Rowley also mentioned a number of cases in which he had experienced serious trouble owing to the mixing of billets. In one case a quantity of differential pinions were made in a steel supposed to be 3 per cent. nickel case-hardening and which later proved to be nickel chrome air-hardening steel, although the billets bore the steel maker's mark of the former class. This is a source of trouble which should

be less prevalent now than during the pressure of war-time conditions in the shops.

Drop-forging troubles due to design are to a considerable extent attributable to lack of drop-forging knowledge on the part of designers and draughtsmen. As the paper put it such workers sometimes do not differentiate between the flow of a molten metal and the flow of a plastic but, at the same time, a solid material. In casting, metal may flow from two directions into the same part of the mould, to form a solid mass on cooling, but plastic metal cannot run together from two directions to form a flawless forging, owing to the oxidation and decarburisation of the exposed surfaces. In this connection Mr. Rowley criticised the usual H section connecting rod as commonly used in internal-combustion engine work. The designer being keen on cutting down weight usually designed a rod with a very small radius in the corner of the flutes. To produce a good forging it was necessary for the flow of the steel to follow the contour of the pattern, but this small radius combined with a narrow section prevented such flow. The result was that metal from the central web tended to flow out into the scrap while that from the sides of the H section also ran straight into the scrap. This caused either a definite crack on "run" extending from the radius to the edge of the fin, or scrap, or else a decarburised streak following the same line. The run might extend only a fraction of an inch, or might actually break through the side of the rod. Mr. Rowley stated that he had examined a large number of rods, both of English and American manufacture, and had usually found the defect present. The obvious remedy was to enlarge the radius in the flute so that the metal might run into the sides of the H section before flowing into the flash. Incidentally a plea was put in for the adoption of a fish-back design of rod wherever possible on the score of the saving in die manufacture.

Another defect which is sometimes produced was referred to. It is clear that with any forging the portion which is in contact with the bottom die will cool more quickly than the top portion, since it is in almost continuous contact with a large mass of comparatively cool steel. This effect may be considerable if the die is a deeply cut one. The result is that with such a material as nickel-chrome steel the lower half of the section will harden so much more rapidly than the top half that the flow of the metal on hammering will produce a shearing action which may result in a crack through the centre of the forging. Mr. Rowley quoted an example of this type of defect, and stated that it was not sufficiently appreciated that a pattern which could be produced easily from a medium carbon steel might not necessarily be suitable for making in such a steel as nickel chrome.

A matter of design which sometimes gave trouble was drastic changes of section. This was particularly brought to notice in parts which had to be heat treated, the quicker contraction of these parts often resulting in cracking. A particular instance of this trouble was mentioned in the paper in connection with some propeller bosses of which the diameter was 85 mm. and the flange only 9 mm. thick. Cracking of the flange was very common after heat-treatment. Failure of drop-forged parts sometimes took place for reasons not directly connected either with the design or the forging. These frequently arose from rough marks left in machining operations which set up "creeping cracks" in parts subjected to alternating stresses. This matter hardly concerns drop forging and we need not deal with it here, but an example of a similar type of trouble which was quoted in the paper arose directly in connection with forging. The case was that of a crankshaft of a 16 h.p. to 20 h.p. car. It broke across one web, but on examination afterwards proved to be of entirely satisfactory material. The clipping tool marks along the line of the flash were, however, very rough and a microscopic examination showed that a crack had started from one of them and was the cause of the failure.

The third type of defects in drop-forgings—those due to the drop-forger—we need not say much about. As already indicated the chief possibility of trouble is owing to overheating, or burning, of the material. It was pointed out that the totally enclosed muffle furnace obviated burning, but was much too slow for rapid production. Muffles with open ports and forced draught were much better, but lent themselves to overheating unless carefully worked, while coke fires were very dangerous especially with alloy steels. Overheating might, of course, take place before a billet reached the drop-forger at all. A final point brought up was that of the distinction between "burning" and "overheating." These terms are frequently used somewhat loosely, but Mr. Rowley considered overheating as a condition which could be remedied by heat treatment, but that metal which was burnt was ruined beyond recovery by any such means and could only be re-melted.

RESTORATION OF PRE-WAR PRACTICES.

An important judgment has been delivered by Mr. Justice Roche in an appeal by the Bentley Engineering Company, of Leicester, from a decision of the local munitions tribunal at Leicester in a prosecution under the Restoration of Pre-War Practices Act, 1919. The case related to the manufacture of screw gauges, but it raised a question of principle of wide and general application in the engineering industry. The company commenced to make screw gauges during the war by means of special screw-cutting machinery which was invented as a result of researches conducted at the National Physical Laboratory. New methods and apparatus for inspection were also invented and were used by the company. The screw-cutting machinery was practically of an automatic character, and the company employed girls on the work of screw-cutting and inspecting. By means of the new machines and apparatus the girls were able to manufacture gauges to a degree of accuracy unattainable before the war by the skilled man working on the centre lathe. The Amalgamated Society of Engineers, relying on the fact that screw gauges were made prior to the war by skilled men, prosecuted the firm under the Restoration of Pre-War Practices Act in order to have them compelled to cease to employ women on the work. The company maintained that the pre-war practice of employing skilled men in the manufacture of screw gauges by the pre-war method had no application to the new methods; that the new machinery and apparatus was of a type which did not exist prior to the war and that to employ men on them would therefore not be the restoration of a pre-war practice. The tribunal—apparently disregarding this contention and the evidence on which it was based—decided against the company—by a majority, we are informed—and held that they were under obligation to employ men on the work. In doing so, they apparently adopted the complainant's argument that as the gauges were made prior to the war by men they must be made by men now, notwithstanding any changes in the manufacture. Now, it is to be observed that previous cases under the Restoration of Pre-War Practices Act had related to processes or the operation of particular types of machines—milling machines, drilling machines, &c.—rather than to the article manufactured, whereas in the screw gauge case the union was driven to treat the process and the machinery as immaterial, for the purposes of the prosecution, as compared with the article manufactured. The success of the union's contention would have seriously hampered the development of automatic machinery, because there could have been little inducement to manufacturers to adopt such machinery if they were to be bound to use skilled labour to operate it. When the case came before Mr. Justice Roche, however, on appeal, counsel for the union acknowledged that he could not maintain his contention, and the case was sent back to the tribunal to be reheard. The rehearing, it is understood, will take place at an early date.

In the course of his judgment Mr. Justice Roche gave the tribunal directions as to the matters to be taken into consideration, and said plainly that the union's contention above referred to was wrong. He added, "Now it is wrong to say that because a thing was made a hundred years ago in a certain way by a certain method, to make the same thing five years or a hundred years afterwards by an entirely different method is the same manufacture or the same industry. To take a simple illustration, nobody would maintain that the manufacture of nitrate products from Chile nitrate, nitrate of soda, is the same as the manufacture of nitrate products from the earth; and if the same principle applies to the making of screw gauges the real question is whether the manufacture or process is the same; it is not whether the result is the same. Of course, the tribunal will recognise that sometimes it is a question of degree, but sometimes it is plain that there is a total difference in the kind of manufacture. If there is a practice or custom to do an operation by a certain class of labour, a mere improvement of method in the performance of the operation will not prevent the practice or custom continuing, or render its restoration impossible or unnecessary. On the other hand, if one method of manufacture is abandoned and another is adopted or substituted so that it is a different method or process of manufacture, then a totally different result follows, and the custom or practice which is applicable to the one method is no longer applicable to the other method. With regard to the screw-cutting, it really depends upon a question of fact, and upon whether it is established that instead of a process requiring skill and experience of very considerable extent there is substituted a process which is virtually or entirely automatic. As to that the tribunal must form their own opinion."

THE ECONOMIC SITUATION OF EGYPT.

The economic situation in Egypt is naturally of interest to British manufacturers when it is remembered that we at present hold nearly half of the import trade of that country in our hands. The figure was actually 46 per cent. in 1919, which, though a good deal below the year 1918 and also somewhat below 1916, is still considerable; while, if we include the Overseas Dominions, the share of the British Empire amounted to no less than 58 per cent. of the total. The situation generally speaking in Egypt, apart from the complicated political aspect of the present moment, is largely one of cotton, fuel and labour, and of these three cotton is predominant. During the war cotton land was restricted. When control was abolished the phenomenal prices to which cotton rose induced greatly increased cultivation—even to the extent of grain and other crops, sown and, in cases, half grown, being ploughed up to make way for the more lucrative industry. The result has been a serious shortage of food-stuffs and the consequent purchase of wheat flour from Australia to supply the needs of a country which in more normal times is not only self-supporting but able even to export.

The changes of recent years are well brought out in a review of the present position compiled by Mr. G. H. Mulock, H.M. Commercial Agent at Cairo, and just published here by the Department of Overseas Trade. The price of cotton nearly doubled in about four months at the close of 1919. At the same time, as a result of the presence of the Expeditionary Force there was an exceptional quantity of money circulating in the country. The price of labour has risen very considerably as a consequence and living is much dearer than formerly. Field labour has doubled in price since pre-war years, while as a result of increases in the rates of child labour cotton-picking is about 10 times as costly as before the war.

Prior to 1914 Great Britain was losing ground in certain directions in which we are more directly interested. The iron and steel imports showed distinct signs of falling off, being unable to compete with the lower prices of Continental products. In 1919 our trade in metals and metal-ware with Egypt amounted to 2,481,495*l.*E., out of a total for this class of 3,742,635*l.*E. We should be able to do better than this at the present time provided we can deliver at a reasonable figure. The amount of money in the country makes the present a suitable time to push sales for iron and steel manufactures, machinery and so on.

In the matter of machinery the present situation is complex and should be studied carefully before embarking on definite lines of policy. With regard to fuel Egypt has always been in difficulties. Coal which is all imported, and which cost before the war, for large contracts, about 22*s.* per ton, now costs

eight or more times that amount, while up country the cost is considerably higher. For the bulk of her oil fuel and refined oils Egypt is dependent also upon imports, and the price of these has of course risen, as with the rest of the world. There is no wood for fuel save the cotton sticks, and for the rest maize and wheat straw, cotton-seed cake and other substitutes are made use of. Normally, of course, cotton-seed cake is exported at a good figure. It is said that there are 11,100 engines of over 50 h.p. at work, and when it is remembered how large a number of the smaller sizes of oil engines have been installed the fuel problem of the future is a serious one. At present Mr. Mulock suggests that the solution is the importation of crude oil in order to obviate reconverting to coal many plants which were converted to oil fuel during the war.

Among the material for which there is a good demand at present is agricultural machinery, bicycles, brass and copper sheets, cement, cheap cutlery, hardware, steel bars, tin plates, &c. Motor cars, four and six-cylinder four-seaters, are said to be in demand. The town dweller of Egypt loves nothing better, when he has made some money by a fortunate transaction or speculation, than to display the fact by indulging in a car and rushing furiously over the few good roads of the country.

Classed with agricultural machinery are tractors for agricultural purposes. In this direction there is strong competition from America. There are at present said to be some half a dozen British makes as well as American, French and Italian, competing for this trade. Owing to the scarcity of draught bullocks and their high price, there is a good opening for these machines, though it must be remembered that there are only 141,522 native owners who hold land to the amount of over 5 feddans (about 5¼ acres), as against over 1,500,000 who own less than that amount. Some 8,000 European proprietors, however, hold estates averaging rather less than 700 feddans. Although demonstrations carried out by individual firms have resulted in a fair number of sales, it is considered that greater advantage to the manufacturer and clients would be secured if central demonstrations were held under the auspices of the Ministry of Agriculture, and an effort is being made to establish these. It is thought that simultaneous demonstrations will result in the best machines securing the market, instead of as is now possible, a poor type spoiling the business for years to come by failing in everyday use after incomplete trials.

NOTES.

Liquid Oxygen as an Explosive.

The use of liquid oxygen as an explosive in metal mines has frequently been suggested, and a good many experiments were made with it when modern methods of manufacture of liquid air were first introduced. The liquid oxygen is not in itself an explosive, but forms a very powerful one when poured into a cartridge charged with sawdust or other combustible matter. When the combustible employed consists of coarse grains or contains but a small quantity of combustible matter, a "soft" explosive is obtained, whilst sawdust or carbon in fine grains yields a violent explosive, and a still more violent one is obtained when the sawdust is replaced by powdered aluminium. Further experiments with this type of explosive are now being made by Les Sociétés Minières de la Lorraine, and of these a description has been given by M. A. Pol in a recent issue of the *Bulletin de la Société de l'Industrie Minérale*. The oxygen required is produced at the works, the plant being driven by an electric motor of 150 h.p. The cost of the liquid oxygen, 99 per cent. pure, is about 1 franc per litre. It is conveyed to the mine in vacuum vessels holding 5 litres each. The cartridges consist of cylinders of strong paper and range from 25 mm. to 40 mm. in diameter and from 15 cm. to 30 cm. in length, and are charged in the factory with the sawdust or other combustible adopted. To prepare them for use, the number required for charging the borehole is soaked in liquid oxygen for 5 minutes to 10 minutes. They are then ready for loading into the hole. This must be done rapidly since the explosive properties disappear as the oxygen evaporates, being entirely lost after the lapse of 15 minutes. If lighted in the open air these cartridges simply burn away, but explode if fired in a closed space. No noxious fumes result from the explosion. As regards effect, a litre of oxygen is said to be the equivalent of 1 kg. of black powder, whilst being very much cheaper.

Houses of Slag Blocks.

In our issue of May 21 last (on page 660) we referred to the manufacture of bricks from blast-furnace slag by the Schol process. The type of houses built of such bricks and slabs by the Rhenish-Westphalian Homestead (Heimstätten) Society of Dortmund, has since been illustrated in *Stahl und Eisen* of July 8. Though intended to provide homes for the labouring classes in the vicinity of the works, the houses may broadly be said to resemble, in their pleasing exterior, semi-detached villas rather than labourers' cottages. The ordinary two-family house is square in plan and consists of a ground floor with cellar and an upper floor, covered by an almost flat, pyramidal roof. A few steps lead up to the two doors; the front has one window in each dwelling on the ground floor and two windows on the upper floor. Each family has six rooms. Apart from the stairway inside and the window frames, &c., the whole house is the work of the mason and built up of slag blocks with cement and lime, mostly made by machinery. All the walls are double and consist of an outer and an inner row of blocks, 120 cm. in thickness, separated by an air space of 60 cm. Spacing blocks, less than 180 cm. in length, nearly reaching across the gap alternately from the outside and inside, are interposed at intervals, and in some of the layers blocks of the full wall thickness, 300 cm., are placed crossways; the spacing blocks are staggered. Thus stability of the walls is secured at the same time as good heat insulation and exclusion of moisture; we gave in our previous Note some figures as to the light weight, high porosity and low thermal conductivity of the slag bricks. Nails take a good hold in the bricks. The ceilings are built up of I-beams, reinforced by iron wire, and of slabs, partly trapezoidal in section and hollow. The roof also rests on beams and slabs; the latter can be made in portable lengths of 5 m., of amply sufficient strength. The large air-cells, both in the upper ceiling and in the wedgeshaped spaces between this ceiling and the roof plates, are said to keep the houses warm in winter and cool in summer. The low, two-floor houses require very little iron; less than concrete buildings would demand. Grooves and conduits for the water pipes and electric wires are provided when the blocks are being moulded, and the building operations take less time than when ordinary bricks and wood are the chief materials. The slag blocks are made of three times the thickness of common bricks.

Signalling by Bare Wires in Earth or Sea.

Many problems have been considered "key problems" during the war. According to General G. V. Squier, Chief Signal Officer of the United States Army, one of these problems was the production of the braiding machinery for finishing insulated wire. The bare wire, the rubber and the cotton for the braiding could all be obtained; but the braiding capacity of the entire works of the United States was by September, 1918, only 8,000 miles of twisted pair insulated wire per month, whilst the American forces alone required 40,000 miles per month, and the Allied Council called for 100,000 miles per month by October, 1918. General Squier therefore tried what could be done with bare wires. Radio signalling ought to be possible considering that two submarines can communicate with one another when both are submerged, so that the wire would merely have to facilitate the propagation of the electro-magnetic waves. It was quite probable, moreover, that both water and earth would, under the action of currents of really high frequencies, exhibit properties very different from those with which we are familiar at direct or low-frequency currents. The experiments on "Multiplex Telephony and Telegraphy over Open-Circuit Bare Wires laid in the Earth or Sea," which General Squier described in the Journal of the Franklin Institute of June last, certainly show the possibility of the suggestion. As is now almost taken for granted thermionic valves (electron tubes, Squier calls them) were used, both in the transmitters and the receivers. In the first experiment a bare phosphor-bronze wire, 1·2 km. in length, was laid across the Potomac River, near Washington; excellent telegraphy and telephony were obtained with a frequency of 600,000 cycles per second. It was at first thought that the exposed end of the wire (perhaps 20 ft.), between the water surface and the apparatus mounted on a staging, might act as an air-antenna; but changes in the length of this wire section made no difference to the signalling. Various arrangements were tried with submerged wires up to 3 km. in length. Wires were also buried in the ground, and it was then expected that, with a line wire ending in the earth, signals would still be received at some distance from the wire end, at spots situated in the direction of the prolongation of the wire. But a thin layer of earth was found to screen the effect completely, in all directions. By means of an exploring coil signals could be overheard when a length of about 5 ft. of the line wire underneath the coil was bared, but all remained silent when the earth was filled in again. This is very important from a military point of view. The Bureau of Standards also made experiments in water tanks, and a resonance-wave coil has been developed, a long helix of many turns, in which stationary waves are set up by the incoming radio signals; the grid of the valve, which serves as detector, is connected to the point of maximum potential on the coil. So far, however, the experiments appear to have been of short range only, and much remains to be done before we can think of bare ocean cables for radio signals. At present Atlantic cabling is limited to waves of a frequency of about 10 cycles and 80 volts, and ocean cable telephony seems to be out of the question. Frequencies of hundreds of thousands would eliminate the wave distortion problems, leaving the prevention of the attenuation as the main problem. Incidentally, it will be interesting to investigate the surface conditions of wires which would prevent the generation of electrons; so far we have mainly studied the conditions favouring the liberation of electrons.

The Lake Ritom Tunnel.

On July 1 last the St. Gothard Railway was for the first time worked by the current from the Lake Ritom hydro-electric power plant in Switzerland. Everything seemed to be in best order at the power station, and the machinery gave no trouble whatever, until at eight o'clock in the evening, 60 hours after putting the turbines under full pressure, some engineers near the plant observed a rock slide, followed by a rush of clear water on one of the slopes about 200 metres to the east of the tunnel which delivers the water of Lake Ritom into the double line of hydraulic pipes going down to the turbine house. Warning was at once given, and the tunnel sluices were closed. Nobody was hurt, and the service is temporarily carried on by auxiliary measures. The facts, so far as then ascertained, were summarised in the *Schweizerische Bauzeitung* of July 10. We have repeatedly referred to the interesting Lake Ritom plant,* and to the notable tapping of the lake by a tunnel conduit, 220 m. in length, which ends under the lake bottom at a depth of 30m. below water level (at the time of the tapping). The tapping conduit joins the tunnel mentioned which is almost horizontal, the gradient being 5 per mille, and has a length of 873 m. The locality of the rock slide mentioned is near the far end of the tunnel, about 50 m. below the horizontal tunnel axis. The dislodged mass of rock has a length of 30 m., and water was streaming out at a rate, roughly estimated, of 150 litres per second. As regards the possible explanation, it is to be said in the first instance, that escapes of water from the tunnel had been suspected, and actually been measured on previous occasions when the tunnel had been put under water. The tunnel section has an area of about 3 sq. m., and the profile is generally of the shape of a horse-shoe, in some parts circular. Fine cracks had been observed in the oval sections, and to stop them a cement grouting had been forced in behind the concrete lining. This operation had been partly successful, but the leakage of water did not cease; the quantity varied

* Engineering, Aug. 25, 1916, page 185, October 6, 1917, page 367, and August 22, 1919, page 20.

with the head of water, and amounted, a fortnight before the accident, to 240 litres per second with a water head of 44 m. above the tunnel bed, and to 26 litres per second with a head of 18 m. What became of this water was not known in spite of experiments with fluorescein. After the accident nine more fine cracks were discovered, but most of these were real hair cracks, only a few having a width of 1·2 mm. From these wider cracks water was seen to rush back into the then empty tunnel. The extraordinary point about these fine cracks, which betrayed themselves by brown lines (iron), is their regular distribution. There are two pairs of longitudinal cracks near the concrete lining of the bottom; some more cracks, also straight, in the walls; and further some oblique cracks, the whole system being symmetrical to the vertical axis of the tunnel. The combined length of the cracks is estimated at 2,000 m. In view of the fineness of the cracks, the losses of water are considered relatively large, and it is suggested that the oblique cracks might be due to shear stresses caused possibly by the gradual transition of the oval section into a circular section under the great hydraulic pressure. The water might also be regarded as infiltrating from the rock and collecting behind the concrete lining which, we should say, was found intact and apparently well laid. The rock in question is not sound; there are dolomites and mica schists, the latter in parts distorted and cleft in two directions. Detailed reports of the accident, for which we may have to wait some time, will be of interest.

Drainage of the Salado Basin in Argentina.—During the war part of a big drainage scheme has been carried out in Argentina which the Dutch engineer Waldorp first investigated nearly thirty years ago. The River Salado, in the province of Buenos Ayres, has a catchment area of about 300,000 sq. km., and an area of 60,000 sq. km. is being drained. Most of the tributaries of this river reach the Salado only in very wet seasons, generally ending in lakes and swamps or losing themselves in the soil; on the other hand, high tides sometimes prevent the discharge of the river. To meet the difficulties Waldorp proposed a system of canals parallel to the main river, the excavated soil to supply the material for high dykes between the river and the canal. Waldorp's successor, the Swedish engineer Nyström̈er, was not able to carry out the original project. But about 1,000 km. of main canals, 350 km. of branch canals, and 150 locks, in addition to many bridges, siphons, weirs, &c., have been constructed, and the work is proceeding. The Salado will have to be regularised. This Salado River which flows south of Buenos Ayres, direct into the Atlantic, must not be confounded with the much larger Salado River in Northern Argentina, which comes from the Andes and joins the Parana.

Queensland's Mineral Wealth.—The annual report of the Queensland Department of Mines shows that the value of last year's mineral output was 2,472,027*l.* a decrease of 1,268,898*l.* as compared with the preceding year. Owing to the sensational slump in copper values early in 1919 the production of this metal almost ceased in Queensland and other States of the Commonwealth. Shipping and industrial difficulties leading to a lack of explosives accentuated the position. One result was that in copper production in Queensland there was a comparative decrease for the year of over 1,000,000*l.* in values, and in tin of more than 100,000*l.*, with serious falls also in lead and silver. Then there was a general gradual improvement with the result that apart from gold the mineral production of the last quarter of the annual term was greater than for the corresponding period of 1918, a promising augury for the current year. Gold mining in Queensland had derived some benefit from the operations of the Australian Gold Producers Association, which in ten months had distributed among its members over 600,000*l.* derived from premiums for the sale of the auriferous metal, but this assistance did not suffice to arrest in any appreciable degree the decline in the output that had been continuous, except in 1915, for the past fifteen years. There was a small decline in the quantity of coal mined in 1919, although there was an increase in the value of the product; the position would have no doubt been much better but for the seamen's strike. The report shows that the value of the gold yield last year was 514,103*l.*, a decrease of 53,208*l.* as compared with 1918. Mount Morgan continued to be the foremost gold producer in the State. Gold mining continued to decline at Gympie, but it was still furnishing some surprises or "streaks of luck." The operations of various copper mines are dealt with in considerable detail, and reference is made to the fact that on the Clonourry, by far the largest contributor of copper of any part of the State, the slump in price that took place in the early months of last year had a most serious effect. During 1919, 54,333 tons of copper ore were treated at the various smelters on the field for a yield of 2,850 tons. The tin production of the State in 1919 was greatly hampered by the drought and by the shortage of explosives in the second half of the year. The same causes also materially affected the operations carried out for obtaining wolfram, molybdenite, bismuth and scheelite in the Cairns hinterland.

LITERATURE.

Sylvanus Phillips Thompson, D.Sc., LL.D., F.R.S. His Life and Letters. By Jane Smeal Thompson and Helen G. Thompson, B.Sc. London: T. Fisher Unwin, Limited. [Price 21*s.* net.]

We are indebted to the widow and daughter of the late Professor Sylvanus Thompson for this attempt to make the world better acquainted with a prominent personality, who for many years occupied an honoured place among the leaders of science progress. We may recall him as an able and renowned electrician, as an expert teacher, as the author of many standard treatises, brilliant as a lecturer, gifted as a linguist, and proficient as an artist in painting and music, but we only know him from the life he led in public. These ladies enable us to make a closer acquaintance with one, to whose lucid explanations from the platform we have listened with pleasure, and whose text books we have read with profit. The references to his home life are restrained but interesting, his many-sided activity allowed him little leisure to cultivate the social life he was so well qualified to adorn, but we could have wished that letters other than those dealing with scientific matters were more plentiful. The progress of invention, the development of mechanical arts, the schemes designed to increase the comfort and well-being of nations are duly chronicled in their proper place, and these, if not character revealing, present with great skill, the general tenor of the thought and work of the subject. Professor Thompson himself gave to the world two conspicuous examples of scientific biography in his "Life of Faraday" and of "Lord Kelvin," and one cannot fail to note that the felicity of expression, the picturesque rendering of detail, the painstaking effort to reconstruct the personality and make it pervade everything in the book, are qualities characteristic of the present biography.

Those who delight in tracing the influences of heredity in developing the capacity and deciding the predilections of succeeding generations, will find ample opportunity in the genealogy of Professor Thompson. His mother was a capable field botanist, his grandfather, John Tatham of Settle, was a chemist and botanist, and in the direct line of ancestry William Phillips, F.R.S., was a geologist, and Richard Phillips, a physicist, the friend and correspondent of Faraday. As his father, who was a schoolmaster at the well-known Quaker school of Bootham, at York, was also a botanist, it is no surprise that Sylvanus acquired the botanical and scientific bent of his family. His capacity as teacher and his powers of exposition may be traced to his father, but his training at the Flounders Institute for teachers was an excellent preparation for one, in whose subsequent career teaching and lecturing played a conspicuous part. From the Flounders Institute at Ackworth, he went to London University, and subsequently to the School of Mines, finally graduating B.Sc. in London University, being first in Science Honours in 1875. He studied much on the Continent, mainly at Heidelberg, and added to his acquirements a very thorough knowledge of French, German and Italian. Years later, on the occasion of the visit of electrical engineers to Italy, when at the tomb of Volta, Dr. Thompson delivered an address in Italian which was listened to with rapt attention, and was much appreciated. All through his life his lingual abilities were of the greatest service in international scientific conferences. He was not one who considered that education in Science alone was an adequate equipment and training for the battle or the engagements of life.

Thompson's first public appointment was to the Lectureship of Physics at Bristol, and the picture that the authors give of the educational movement in that city is not very pleasant reading. Ambition seems to have outrun means, and with the best intentions on the part of the promoters to raise the standard and increase educational facilities, they did not appreciate what was necessary for the full realisation of the scheme. Professors and students had to endure inconveniences that would now appear intolerable. Government subsidies at that time were not forthcoming, and with funds accumulating but slowly, difficulties increased to such a point that the management proposed, on account of economy, to drop the arts side of the University College. We have heard much of late of an undue prominence given to literary subjects in the educational curriculum, and at times the views of scientific men have been so misrepresented as to suggest that they advocate the suppression of classical teaching. It may therefore not be out of place to record, that forty years ago, this distinguished scientist fought strenuously on behalf of literary education. Of the proposal to discontinue arts training he wrote "if carried out it will effectually cripple the literary side of the college, and for that reason, if for no other, I should regard it as disastrous to the prospects of the college. We owe it to the influence of Oxford . . . that our college has not been confined in its aims to being merely a science college. To draw back now would be little less than fatal."

At the same time, no man had clearer notions of the proper function of technical education, its possibilities and its limitations. When at Bristol he found the difficulty of getting pieces of apparatus accurately made from his own designs. In many cases it was necessary to employ foreign workmen, and he thus early recognised that electrical, chemical and optical industries were hampered by failure to give instruction in the general principles of science, that underlie handicraft trades, and that the commercial prizes of the future would fall to those countries whose artizans were the most trained and skilled. This doleful story, he urged, in practically the words that have since been repeated by many in recent years, who have been painfully aware of the hopelessly inefficient training given in the workshops of this country. "Belittle the teaching of science" was his cry, "ignore the expert trained in science, carry on your works without him. . . . then, when after years of neglect you find the progress which ought to have been made here is made in foreign countries, blame the patent laws, blame the lack of protective tariffs, blame the trades unions. Blame everything, but the blindness of manufacturers and men to the truth, that that industry is doomed the leaders of which despise and neglect science."

It was fortunate that a man of this temperament was elected Principal, and Professor of Applied Physics in the City and Guilds Finsbury College. The position gave him the opportunity of urging sound views on the subject of technical education and ensured the adoption of a high standard. He drew a clear distinction between a technical college and an academic institution, never confusing the function of the one with that of the other. The training he aimed at giving was to be professional rather than scholastic. The work of the principal might be less ambitious and less dignified than that of a university professor, but, if different, was not less valuable or less necessary. Unwearying industry, ardent enthusiasm, and unfailing energy were required from the holder of these views, and these qualities Thompson could and did give without stint. For more than thirty years he directed the fortunes of the Institute with ability and success and his reputation must rest on what was the main occupation of his life. His other work, great and varied as it was, must be regarded as an ornamental fringe to his professional career. In saying this we do not overlook the fact that the number of his communications to learned societies approached 200, of which some 150 may be regarded as of prime importance in furthering our knowledge of every branch of physics. As a scientific lecturer he was probably unrivalled since Tyndall, and as a writer of text books he enjoyed and deserved a wide popularity. His "Elementary Lessons on Magnetism and Electricity" run through more than 40 editions and reprints, and in translations has been read from China to Peru. The treatise on "Dynamo Electric Machinery," appeared in seven editions and also was widely translated. It is only necessary to mention his "Electro-Magnet," his "Polyphase Electric Currents and Motors," and his "Light, Visible and Invisible," to recall the world's indebtedness to this gifted and voluminous writer. His share as "Brother Magnetiser," in the "Sette of Odd Volumes" and his "Calculus Made Easy," whose authorship was never publicly admitted during his lifetime, reveal Thompson in another, but not less attractive, light. Nor must be omitted Professor Thompson's keen interest in, and wide acquaintance

with, the history of science. His knowledge was thorough and gained at first hand. This is well illustrated by his contributions to the literature published on the occasion of the tercentenary of the death of William Gilbert of Colchester, Physician to Queen Elizabeth. He annotated and reprinted some of Boyle's work on magnetism and also translated from the Latin an epistle on Magnetism by Peter Peregrinus, a soldier of fortune of the thirteenth century. His biography of Phillip Reis, the inventor of a telephone that in some respects anticipated the work of Alexander Bell, was a model of care and industrious research. His patient and determined effort to collect all possible information, and his precise sifting of facts was characteristic of the man. To acquire the minute knowledge he possessed demanded the formation of a library of a particular kind. His taste as a collector and his proclivities as a bibliophile found ample scope in the accumulation of a large number of rare pamphlets and incunabula. The whole collection of books, ancient and modern, many of them enriched by marginal notes from Thompson's pencil, will be preserved in its entirety at the Institution of Electrical Engineers.

It is not a little remarkable that though Professor Thompson was eminently successful as a professional scientific adviser, he was not known as an inventor. As a young man he was interested in the beginnings of telephony and invented a form of valve telephone, which, however, was held by the courts to be an infringement of the Bell-Edison patents, Mr. Justice North holding that "every surface which can vibrate is a diaphragm.' Later he devised a mechanical arrangement for securing a distortionless cable, founded on Heaviside's well-known equation, but the form of inductive leaks he proposed never came into practical use, and Pupin's loading coil, though later on the market, has been adopted in preference.

As is well known, Professor Thompson belonged to the Society of Friends, of which he was a sincere and attached member. He was heartily opposed to militarism as shown by his conduct in the Boer War, and in the long struggle now happily ended. But such matters scarcely belong to public comment. Whatever views he held they were the results of sincere conviction, and his attitude is well expressed in such works as "A Not Impossible Religion," and the "Quest for Truth." His place in literature, in science, and in the arts is assured, but this book is not the less necessary for the public, while its appearance will be welcomed by those who were privileged to enjoy his acquaintance.

Forest Woods and Trees in Relation to Hygiene. By Augustine Henry, M.A., F.L.S., Professor of Forestry, Royal College of Science, Dublin. London: Constable and Co., Limited. [Price 18s. net.]

A few years ago afforestation was a word to conjure with. Advocates disregarding the cautious attitude of trained experts recommended its adoption as affording pleasant occupation for the unemployed; a welcome addition to the amenities of unpicturesque localities, and effective as a source of revenue, by utilising large tracts of waste land which had proved unsuitable for tillage and unprofitable for grazing. This pleasant vision, or at least its more agreeable features, had its origin in a mistaken view of the requirements and fitting education of the forester, who was too frequently regarded as a rougher kind of gardener, who mechanically planted trees according to a given plan, relying for his information concerning tree taxonomy on the botanist, drawing his knowledge of sites suitable for the growth of different kinds of trees from the soil physicist and geologist and looking to other specialists for protection from tree disease and the evils wrought by insect enemies. Forestry has too frequently been regarded as a patchwork of miscellaneous knowledge, borrowed as emergency arises from other sciences, to eke out the operations of unskilled labour on which the industry is supposed mainly to rely. Professor Henry's book should convince the uninformed that forestry is self-reliant, occupying a worthy and distinctive place in applied science and founded upon a knowledge of the life of the forest as such. Here the forester is seen not availing himself of the researches of others, but advancing into the domain covered by sanitation and showing how forestry in some directions benefits the community, and on that ground is deserving of study, support and consideration.

Professor Henry in a preliminary chapter discusses the effect of forest on climate, and would seem to sympathise with those foresters, whom Humboldt reported as saying "How foolish is man in destroying mountain forests, as thereby he deprives himself of wood and water at the same time." This saying contains a popular error, that needs correction, for the effects of human agency in influencing the amount of rainfall is probably too small to be detected. The cold bare soil of the mountain should cool the air in contact with it, more rapidly and effectually than the crowns of trees, and for that reason promote precipitation. Adiabatic expansion and cooling, another frequent cause of rain, would operate more thoroughly on the hill sides when deprived of vegetation, so that one can hardly regard forest destruction as a factor tending to diminish rainfall. The author gives no scientific support to this fallacy; he remarks that great climatic changes of cosmic origin occur in the course of centuries, and it may be that lessened rainfall has occasioned the disappearance of the forests rather than that the removal of the forest has diminished the rainfall. After the rain has fallen, the destruction, or the creation, of forests is capable of exercising very noticeable effects on several climatic factors, effects that have been confounded with the promotion or withholding of rainfall. From the foliage, the amount of transpiration is increased, and consequently the humidity on the leeward side is greater, also by acting as a wind-break the trees reduce the force of the wind in the lower layers, and tend to prevent evaporation, which depends greatly on the wind velocity. But most important of all is the effect on the run off, which on the denuded mountain slopes may assume a distinctly altered character. If a forest is standing, the litter and humus under the trees absorb much of the rain, making percolation through the soil much slower, the melting of snow is delayed, floods reduced, and much less detritus carried in the streams from erosion of the banks. River navigation may be injured by the accumulation of stones, and when the river bed is filled with transported sediment, a slight rainfall may cause a disastrous flood. In these days, the conservation of water is becoming of prime importance as a source of power, and these questions will be studied from an economic as well as from a hygienic point of view, for scientific opinion is divided as to the manner and extent of action of forests in influencing river floods.

As touching hygiene simply, the protection afforded by forest shelter is admitted to be beneficial. Humid winds at low temperature decrease the vitality of all living things, animal and vegetable. Confining attention wholly to the problem of afforestation, it is found that the consequence of such winds is to dwarf the trees in size, and to distort them in shape. In extreme cases, trees are prevented from rising above the ground owing to strong winds damaging the tissues. In still air, though coupled with extreme cold as in Northern Siberia, large forests are still possible, and acting as a shelter permit crops to grow that would not otherwise succeed, while domestic animals fatten, enjoy vigorous health and produce an increased supply of milk. Shelter belts, though of little value as timber, may be of great economic importance if they could be made to afford protection, and permit a larger acreage to be devoted to husbandry. In both Scotland and Ireland much sheltering might be provided. The bracken lands of Scotland which are valueless for grazing could be easily planted with trees without interfering with the mountain pasture industry. Grass would grow better and sheep farming would prove a more profitable undertaking. In Ireland, the peat bogs act as centres of cold causing late spring frosts, which in various ways are detrimental to agriculture. To minimise this evil, the author recommends that peat bogs should be surrounded with plantations which can be easily and cheaply established in the cover margin of the bog. By such means, large areas of waste land, for land not occupied to the best advantage of the community is really waste land, will support stretches of wood that can be worked on a commercial and profitable scale, with systematic fellings that will ensure a permanent continuity of supply and yield a profit over and above the cost of upkeep. Indirectly, too, such areas will operate beneficially, for the care of the forest land will demand more labour than the pasturing of sheep, and other industries as saw mills and pulp mills will serve as centres to new and thriving trades.

In this country, it is not possible to form forests in the sense in which the word is used on the Continent. The aggregate of many small areas must be substituted for the large and continuously tree-covered surfaces that are to be found in Russia and Germany. The author accordingly asks where is sufficient acreage to be found in this densely-populated country, and how are the expenses to be met, expenses that will be the larger as the subdivision is greater. It is impossible to do justice to the author's argument and programme, but reference may be made to two suggestions, founded upon actual operations, which deserve recognition and extension. One is the afforestation of water catchment areas, of which a complete list with their latent possibilities is given. The plan is to be recommended on two distinct grounds, the importance of increasing hygienic measures and the main purpose of afforestation, the increase of timber reserves. Many catchment reservoirs have been formed to impound the water falling on uplands and sparsely peopled districts, and to these may be added the land adjacent to natural lakes as at Thirlmere, monopolised by Manchester, and Loch Katrine by Glasgow. From a sanitary point of view it is highly desirable to prevent pollution of the water, and when authorities have only leased the water rights and not acquired the ownership of the gathering grounds, the protection afforded is usually inadequate. When houses or farms exist on the gathering grounds serious impurities may be, and are, swept into the reservoir. The sanitary authorities of the town owning the waterworks may have no jurisdiction over the gathering ground, which is probably perfunctorily cared for by a rural sanitary authority. The difficulty of maintaining a high standard of purity of water for domestic consumption has led several of our great cities to acquire the ownership of the catchment area, but on a considerable number of gathering grounds, habitations and farms have been allowed to remain, chiefly owing to the large sums demanded for the fee simple. In these cases, neither can afforestation be carried out satisfactorily nor can pollution be efficiently guarded against. Professor Henry urges, and rightly, that steps should be taken to secure both ends. The fiscal arrangements, however, are difficult and the adjustment of terms under which land is to be fairly acquired demands nice handling for reasons which are fully set forth and should be read by those who are interested in the legal aspects. The scientific side, however, is not less interesting than the financial, and an able guide is necessary, for few have studied forestry as a branch of economic industry. The advice of the expert is needed at every stage for intuitions and predilections do not suffice. The choice of trees is not a simple matter, for a forest may be likened to a community in which the individual trees influence one another, and also the character and life of the community itself. The life history of the forest community varies according to the species composing it, the density of the planting, the manner in which the trees of different ages are grouped, the climatic and soil factors, which affect the vigour and growth of the individual trees. An impression obtains that if Government gives an order and finds the money all the difficulties will be removed, and an ordered plan will go forward. This is not necessarily the case. Doubtless some plan might go forward, but one that is likely to lead to disappointment and loss. It is easy to injure a forest as a living entity, and skilful treatment is required to ensure a high class of product. Trained forestry officers are needed to secure success, and at the present moment it is not easy to see whence these are to be obtained. The scattering of the localities over a wide area points to the necessity of a large staff, and it is doubtful if the construction of woods of approximately 500 acres, or less, is economically sound.

The second suggestion of Professor Henry is on

more modest lines, but in one that will meet with ready sympathy from many. It aims at removing the desolate aspect created in many parts of the country by mining and manufacturing operations. The heaps of slag, shale, and trade wastes, that disfigure the country have a depressing effect on the population, and aggravate the bad effects of a dust-laden atmosphere on the physical and moral health of the people. He would cover each of these eyesores with the growing trees suitable to the site. In the case of catchment areas perhaps 200,000 acres could be added to the resources of the nation, but the total area of the pit mounds would probably not amount to more than one-fourth of this acreage in the aggregate, and each site would be of small extent. The object here is to beautify the landscape, rather than to produce profitable timber, though one colliery is known to have grown some of its own pit props on its own spoil heaps. Some will hardly have suspected that a soil so poor can be turned to forestry use, and made to support a plantation of selected trees. The coal waste which often burns for years produces, however, a red and friable ash, in which trees will grow fairly well, but in the more sterile localities only a few specimens are sufficiently hardy. Voluntary associations have made valuable experiments, and as a result it is now recommended to plant only two or three-year-old seedlings. The trees which give the best results are the Sitka spruce, larch, Scots pine and the common alder. On weathered mounds on which grass will grow, the ash, sycamore and wych elm thrive fairly well. A particularly pleasant feature is the interest shown by the children in the process of planting and care of the trees. The eagerness displayed is very gratifying, and the French, in particular, have made of the idea a great success. In 1910, the school children planted some hundreds of acres with more than 2,000,000 trees, but it is something to have succeeded in inspiring a civic sense in the boys who guard and protect the young trees, checking the spirit of vandalism, sometimes exhibited. More successful, as more ambitious results can easily follow.

Professor Henry, writing as much on behalf of hygiene as of forest economy, supports the movement warmly, and adds many interesting features.

The British public, dwelling largely in towns, knows very little of trees, and has been careless to promote and establish a continuous policy of tree planting and waste land development, that would react favourably on social organisation. This indifference arises in some measure from the absence of adequate guides and trustworthy information. The author shows that he is competent to lead, and his book well fills a vacant gap in woodland literature.

BOOKS RECEIVED.

Résistance des Materiaux et Elasticité (*Cours Professé a l'Ecole des Ponts et Chaussées*). Par GASTON PIGEAUD. Paris: Gauthier-Villars et Cie. [Price 64 francs.]

The Engineering Index, 1919. New York: American Society of Mechanical Engineers. [Price 4 dols.]

The Journal of the Institute of Metals. Vol. XXIII. Edited by G. SHAW SCOTT, M.Sc., Secretary. London: Published by the Institute, 36, Victoria-street, Westminster, S.W. 1. [Price 31*s.* 6*d.* net.]

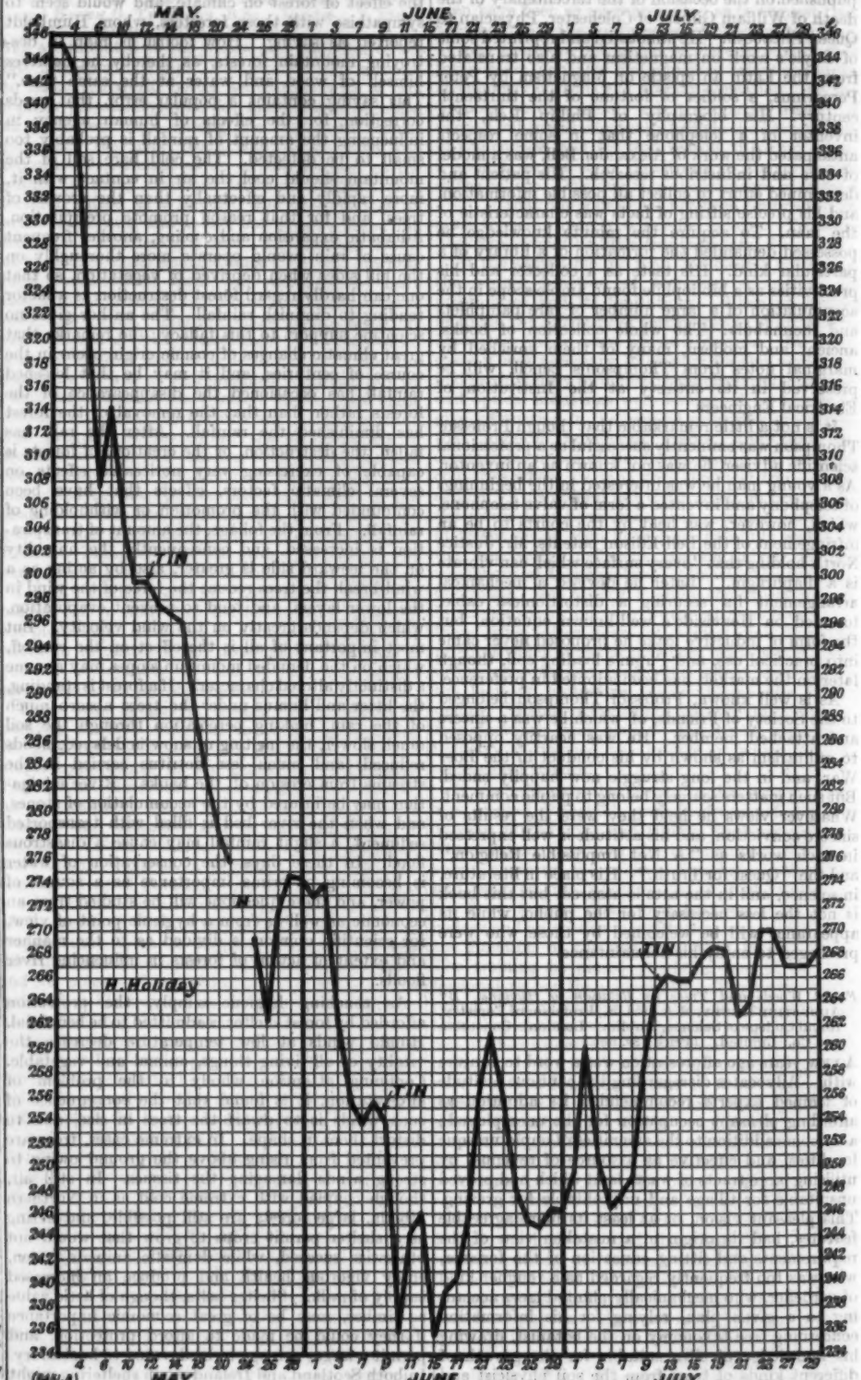
United States Bureau of Mines. Bulletin No. 181. *Abstracts of Current Decisions on Mines and Mining. Reported from January to May*, 1919. By J. W. THOMPSON. [Price 15 cents.] Miners' Circular No. 26. *Miners' Safety and Health Almanac for* 1920. Compiled by R. C. WILLIAMS. [Price 10 cents.] Technical Papers No. 211. *Approximate Quantitative Microscopy of Pulverised Ores, including the Use of the Camera Lucida*. By WILL. H. COGHILL and J. P. BONARDI. [Price 5 cents.] No. 257. *Waste and Correct Use of Natural Gas in the Home*. By SAMUEL S. WYER. [Price 5 cents.] Washington: Government Printing Office.

Oil Fuel Burning in Marine Practice. A Manual of Practical Instruction in Oil Fuel Burning intended for the Use of Naval and Mercantile Marine Engineer Officers, &c. By J. W. M. SOTHERN. Glasgow: James Munro and Co., Limited. [Price 30*s.* net.]

CAPITAL AND INCOME TAXES IN BULGARIA.—The Commercial Commissioner to H.M. Legation at Sofia has forwarded to the Department of Overseas Trade summaries of the new laws which have been instituted in Bulgaria. These laws consist of the following: (*a*) War profits tax; (*b*) levy on capital; (*c*) income-tax, and (*d*) companies' tax. The summaries of these laws may be consulted by persons interested at the Department, 35, Old Queen-street, London, S.W. 1.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)

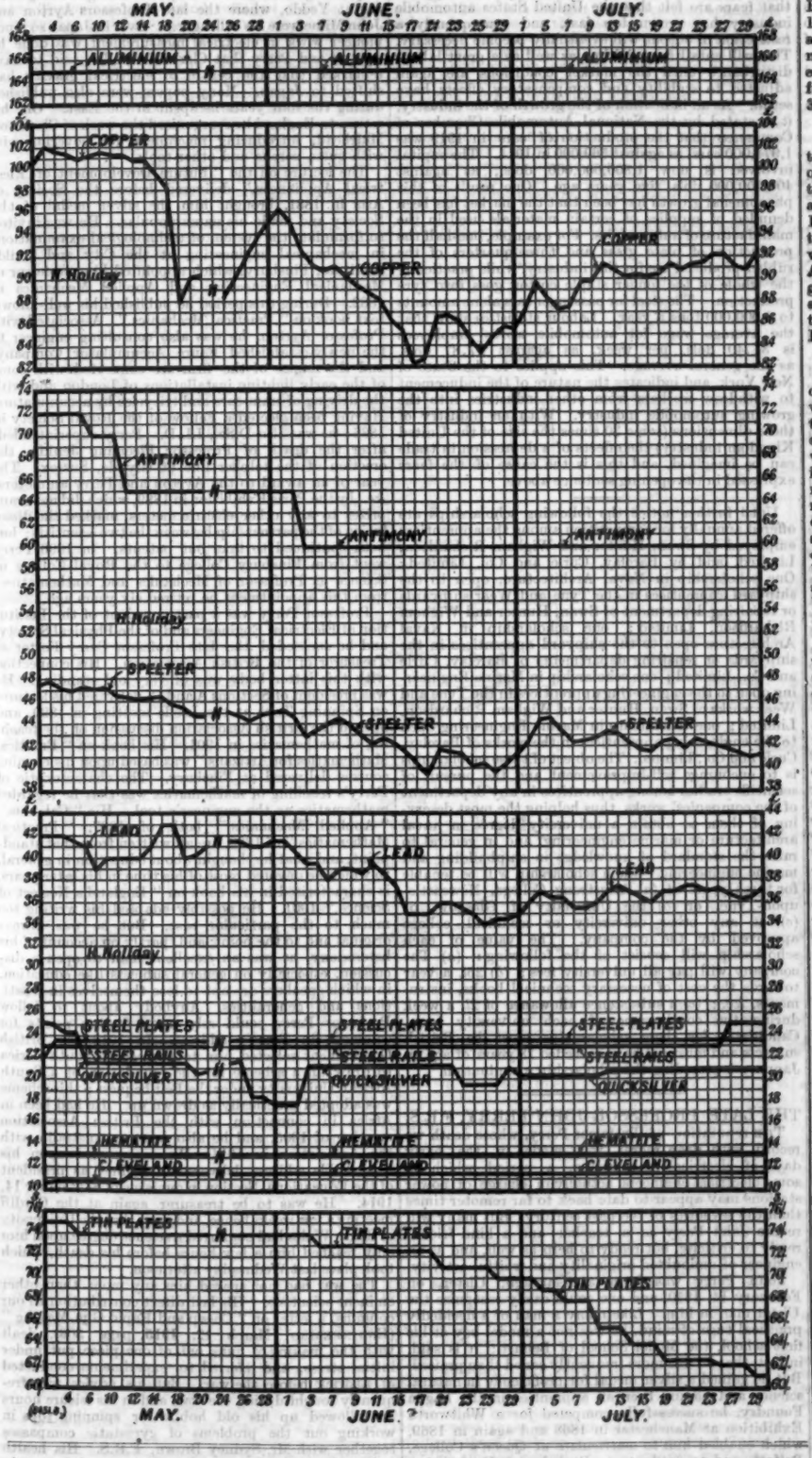


NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates, are for ship, bridge, and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin plates is per box of I.C. cokes free on board at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin plates, where they represent 1*s.* each.

REVIEW IN SPANISH OF THE BRITISH MARKET.—Messrs. Rownson, Drew and Clydesdale, Limited, 225, Upper Thames-street, E.C. 4, have issued in Spanish a review of the market, dated July. They call attention to their large purchase of Government stores which they are able to offer for immediate delivery. The pamphlet gives quotations for freights to various parts of the world for a number of goods, and prices for a large quantity of tools, for paints, lubricants, &c., and should help foreign buyers in their trading with these enterprising merchants.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



THE COAL OUTPUT OF SOUTH AFRICA.—We read in the *S.A. Mining and Engineering Journal* that the Transvaal coal output for May was 590,504 tons, valued at 168,825*l.*, or 5*s.* 8·62*d.* per ton at the pit's mouth; the production of Natal was 290,528 tons, valued at 181,400*l.*, or 12*s.* 5·85*d.* per ton, also at the pit's mouth. The figures for the Union of South Africa were, 72 collieries producing, total output 957,221 tons, valued at 372,372*l.* In the Union 8,242 tons of coal were converted into by-products during the month, and there were produced 1,854 tons of coke, 3,595 gallons of tar, and 235 tons of sulphate of ammonia.

INDUSTRIAL NOTES.

We are informed that following negotiations recently held, an increase of 25 per cent. has been granted to workmen employed in steel smelting throughout Great Britain, the increase coming into operation as from the 1st inst. An increase of 35 per cent. has been granted as from the same date to the workmen in the rolling mills and puddling shops in the Midlands; whilst men employed at the Northampton and Lancashire blast furnaces are to receive increases in their wages of 35½ per cent. and 55½ per cent. respectively.

The National Federation of General Workers asked the Employers' Federation, last week, for the re-opening of negotiations on a national basis following the recent sectional strikes among gas workers. The application includes a demand for a further increase of 1*s.* a day or shift. It is stated that a conference with the employers will be arranged for shortly. We dealt with the situation in the gas industry on page 48 *ante*. At the time of writing, it is announced that the Wigan gas workers have struck for the full 10*s.* per week advance that was originally demanded. In so doing, they have disregarded the advice of the National Federation.

A conference of delegates from men engaged in commercial road transport throughout the country was recently held in London, with a view to deal with the failure of the Industrial Council to arrive at a decision in regard to the men's demand for a minimum wage of 4*l.* 7*s.* a week for one-horse drivers, with increased wages for higher grades. Replies were received from unions respecting a strike in the event of negotiations failing. The conference decided that a deputation from the Transport Workers' Federation should interview the Minister of Labour with the object of arranging for a conference with the employers, both those who are parties to the Industrial Council and others. In the meantime, no steps are likely to be taken.

The Industrial Council has not approved the claim of the National Union of Railwaymen for an increase of 4*d.* per hour on the pre-war rate, plus the recent 6*s.* advance, the 33*s.* 6*d.* a week and the 12½ per cent. war wages, for the men employed in the railway companies' electrical power and sub-stations belonging to the controlled railways of Great Britain; the Court has accepted the contention of the railway companies that the existing rates and conditions of service instituted for the London district be confirmed and that the rates obtaining in London be extended to similar grades of workers in the provinces, less 10 per cent., except in the case of Glasgow, Liverpool and Manchester, where the rates would be 5 per cent. less than in London. As regards the stations which supply railway workshops with lighting current, the Court decided that the conditions of service shall be the same as those obtaining in the workshops of which the power stations virtually form a part. The decision is to have effect on and after December 1 next.

It is reported that six unions are taking a ballot of cable workers on the question of ceasing work to enforce a claim for an increase in wages of 15*s.* a week for workers 18 and over, and 7*s.* 6*d.* a week for those under 18, with a 33½ per cent. guarantee for piece workers. Following upon meetings of the Industrial Council, the Cable Makers' Association offered a further war advance of 5*s.* per week to male workers of 18 and over, payable as from August 1, and an increase of the minimum for women 18 and over from 41*s.* to 43*s.* The ballot papers state that the offer, in the opinion of the affiliated societies, is wholly unsatisfactory. The ballot is returnable by next Monday.

It is often stated that this country is a free country, but such is not actually the case, as the following instance clearly indicates. Last week, 2,500 miners of the Manton (Worksop) Colliery, of the Wigan Coal and Iron Company, ceased work, because three or four of their fellow workers belong to the Winding and General Engineers' Society instead of belonging to the Yorkshire Miners' Association, of which they are members. The three or four men in question maintain that they are fully at liberty to belong to the union they like best. Hence the strike and the loss in output of about 2,600 tons of coal per day.

A correspondent writing to *The Yorkshire Post* from Tonypandy, states that to-day the Rhondda Valley is rich beyond its wildest dreams of former times; the lowest wage for an adult miner is 5*l.* 7*s.*, and the majority earn twice or three times that amount. Yet these same men are preparing to imperil industry and destroy the stocks of winter coal by striking for a further 2*s.* a day. As it is, the stocks of bunker coal

are so low that the sailing of ships from Cardiff is frequently delayed. In cold, official language, the Miners' Federation is demanding an increase in wages of 2s. a day over and above the present increase of 154 per cent., and a reduction of 14s. 2d. a ton in the price of domestic coal, in order to swallow up a surplus of 66,000,000l. made on export coal and intended to become in effect excess profits duty for the benefit of the country. At one of the largest collieries in the country, some 12,000 men are employed. The total wages bill has increased since 1916 from 40,000l. a week to its present colossal figure of 160,000l., and at the same time production has greatly fallen off.

Speaking at Forest Town, near Mansfield, last Saturday, and dealing with the Government control of the coal industry, Mr. J. P. Houfton, late managing director of the Bolsover Colliery Company, said the people had been told that all development had ceased, and that this was partly the reason the nation should take over the collieries. During the period of the war, however, 20,000 acres of coal had been taken over ready for development as soon as the Government would give a chance to develop it. Did that, he asked, show want of enterprise or faith in the future? He had, personally, as much faith in the future of the coal industry in this country as in the country's future. There existed a feeling of uncertainty as to the future of this great key industry. He agreed that during the war the Government should control every ton of coal brought to the surface in order to assist to victory, but it was now nearly two years since the armistice was signed, and the collieries were still controlled, with the result that a good deal of uncertainty as to the future of the industry still existed. People hesitated to spend money on developments, and all felt that what they had worked and paid for with the hope of prosperity was not only controlled but threatened with extinction of ownership. Could people, therefore, be surprised if men, who were far-seeing and had proved themselves able men in the development of the coal industry, hesitated to do all that they might, until they were assured that they would receive back fully all they spent? There were people prepared to find money and to a still greater degree develop the coal and other minerals in this country, if they could only be assured that no extremists or Socialists would shake the Government in its determination to support those who risked their capital.

We take the following notes from *The Newcastle Daily Chronicle*; they give interesting information on the miners, the dockers, and on the pay of the latter:—

"There is a serious unrest among the dockers. The slump in the docks has given new life to an old flame of jealousy between dockers and miners, and the strength of the Triple Alliance may be sapped away if the latter get fresh concessions." This grave warning was uttered by a trade unionist who has worked in the docks for over thirty years. He believes that the miners are being regarded with increasing disfavour by the other section of the Alliance. "I do not claim to speak for the leaders and agitators of course," he further stated, "but I live among the men themselves and their feelings are very different from those of the trade union official who sits in his office, blissfully aloof from any reality beyond a feverish race for more wages. Never before have the men had such high rates of pay, and yet they are dissatisfied. There is some truth in the statement of a labourer giving evidence at the Central Criminal Court recently, that since the last increase of pay work at the docks has been very bad. One very obvious cause of this is piece work. Men are not going to work in the normal way if they can get double rates by doing piece work, and together with the thirst for overtime the balance of labour is upset. The dock labourer is entitled to 16s. a day under the Port of London agreement, and 17s. 6d. a day working for a contractor. But he prefers piece work—which the union pretends to condemn. I have known men earn as much as 2l. to 2l. 10s. a day on piece work. Since the increase of pay there has been an influx in dockers' ranks of men from less highly-paid trades, and this has helped to make the slump. July is always the worst month of the year, and the importance of the present depression must not be exaggerated. The real trouble goes much deeper. It is a delusion to suppose that any real unity exists between the miners and the dock labourers. The miners are at the bottom of all our troubles in the docks because they are the most successful in the policy of grab. The coal export has decreased so enormously—in spite of the grandiose promises of Mr. Smillie—that the dock labourer has been badly hit. The average worker regards it as a stab in the back. In other words, he is jealous. The unemployment caused by the fall in exports has created much bad feeling among the dockers. Speaking as one who knows their conditions and psychology from the inside I am apprehensive for the future. I predict a grave unrest starting from the dockers, and possibly spreading throughout the entire labour world if the demand for another increase of wages (to the miners) is granted."

From a recent report received in the Department of Overseas Trade, from an American source, it appears that fears are felt that the United States automobile industry has grown too fast, and consequently a restriction in output will eventually become necessary. This will entail financial loss as well as a great labour disturbance until the market conditions are again adjusted to stability and compensatory effects have set in. As an indication of the growth of the industry, it is stated by the National Automobile Chamber of Commerce that the production of cars in 1919 was 1,974,000 cars, as against 569,000 in 1914. The capital involved is now 1,800,000,000 dols., as against 400,000,000 dols. five years ago. One result of this phenomenal growth has been that the market has been denuded of supplies of certain materials used in the manufacture of automobiles. For example, one-half the production of plate glass and three-quarters of the rubber produced are for this industry, while practically the whole of the longer staple cotton goes into tyre production. The steel for passenger cars alone amounts to 2,000,000 tons a year. Labour statistics show that the average wage for automobile works' employees is 31.40 dols. per week, as against 27.87 dols. as the general average. This applies to the State of New York, and indicates the nature of the inducement to withdraw workers from other industries into the growing automobile industry. With an industry of these dimensions (some 30 times the size of the United Kingdom industry) the effects of a depression in trade can be imagined, and this is the cause of the fears expressed in the opening sentence above.

Until further notice the following scholarships are offered annually for competition among the apprentices employed by Swan, Hunter and Wigham Richardson, Limited, and by Barclay, Curle and Co., Limited: One scholarship in Naval Architecture, open to the shipyard apprentices in the Tyne and Wear shipyards or repairing department of Swan, Hunter and Wigham Richardson, Limited; one scholarship in Naval Architecture open to the shipyard apprentices in the shipyards or repairing departments of Barclay, Curle and Co., Limited; one scholarship in Marine Engineering open to the engineering apprentices in the Tyne and Wear works of Swan, Hunter and Wigham Richardson, Limited; one scholarship in Marine Engineering open to the engineering apprentices in the works of Barclay, Curle and Co., Limited. The object of these scholarships is to encourage self-improvement and the pursuit of scientific studies among apprentices in any department of the companies' works, thus helping the most deserving of them to obtain a university degree in naval architecture or marine engineering, and in general to raise the standard of knowledge in shipbuilding and marine engineering. Each scholarship will be tenable for three years at (*a*) Armstrong College, Newcastle-upon-Tyne, or (*b*) the University of Glasgow, or (*c*) at any other university or technical college approved by the company. The value of each scholarship will consist of the following: (*a*) The company will pay all university fees; (*b*) 25l. a year towards the cost of necessary technical books, instruments, &c.; (*c*) a subsistence allowance of 2l. a week during the continuance of each university term. Candidates for these scholarships must be British subjects and must not have exceeded 18 years of age on January 1 preceding the scholarship examination.

THE LATE PROFESSOR JOHN PERRY, F.R.S.

THE reputation of Professor Perry, whose death we record with deep regret, was made in the early days of electrical engineering, a period which to some electrical engineers actually in charge of power stations may appear to date back to far remoter times than the seventies of the past century. But many will revere John Perry as a teacher and a kind friend, ready to criticise, but ready to help as well, and as an engineer of undoubted originality and fruitful activity.

John Perry was born at Garvagh, Ulster, on February 14, 1850, and one could easily recognise the Ulster man in him. Like many a man of a decidedly practical turn of mind, he was not a model boy at his first school, the Model School of Belfast; it is said, in fact, that he was more frequently caned than praised. But he gained a silver medal for proficiency in natural science and having been an apprentice in the Lagan Foundry, he successfully competed for a Whitworth Exhibition at Manchester in 1868 and again in 1869, which enabled him to matriculate at Queen's College, Belfast, and to graduate as Bachelor of Engineering in 1870, after only two years of study; the degree of Master of Engineering followed later. He took various other prizes, including a Whitworth scholarship of 100l., and continued to work in the shops of the Lagan Foundry in winter. In 1871 he was offered the mastership in Physics at Clifton College, where he introduced a physics laboratory and school workshop. Having published his book on the "Steam Engine" in 1874, he became assistant to Sir William Thomson at Glasgow in 1875, and was there tempted to accept the professorship of engineering in the Imperial College of Engineering at Yeddo, where the late Professors Ayrton and John Milne were his colleagues. Over in Japan so much pioneer work in electrical measurement was done by Ayrton and Perry that Clerk Maxwell is said to have remarked that the centre of electrical gravity had shifted to Japan. Many papers were also published during the four years he spent in the East. On his return to England he reorganised the work of Clark and Muirhead, introducing machinery for covering wire with gutta percha and other tools.

The lecture on the "Future Development of Electrical Appliances," delivered before the Society of Arts in 1881, brought him the silver medal of the Society and made his name popular. He was invited to formulate the system of technological examinations in mechanical engineering at the City and Guilds Institute, Finsbury, which appointed him professor of Mechanical Engineering and Applied Mechanics in 1882. During this period he published his well-known text book on "Practical Mechanics." Associated with Professor Ayrton, he was also consulting engineer to the newly-established Faure Accumulator Company, and the names of the firm are connected with some of the early lighting installations of London and with the driving of tram-cars and tricycles by accumulators. Having been elected a Fellow of the Royal Society in 1885—he was also D.Sc., LL.D.—Perry superintended, after the death of Professor Fleeming Jenkin, the erection of the telpher line at Glynde, Sussex. The year of an award to the Ayrton and Perry ammeters, &c., by the Paris Exhibition in 1889, which did not grant prizes to any other electric meters, marked the dissolution of the partnership between the two scientists; but both continued to take out patents. In 1896 Perry went from Finsbury College to the Royal College of Science as Professor of Mechanics and Mathematics; from this appointment he retired six years ago.

Professor Perry was a past-president of the Institution of Electrical Engineers and of the Physical Society, and he succeeded the late Professor Carey Foster as Treasurer of the British Association. His connection with this latter body was of very old standing. He was president of Sections A and G, delivered his lectures on Spinning Tops at the Leeds meeting in 1890, and opened the British Association discussion on the teaching of mathematics in 1901. His book on "Practical Mathematics for Artizans" was based upon his evening courses delivered at Finsbury. The characteristic of Perry's teaching of mathematics was that he regarded mathematics as the engineer's tool. His "Calculus," "Applied Mechanics," both of 1897, "Practical Mathematics" of 1899, are all written from that standpoint, and what he thought about education in general, to which he devoted most of his time in his later years, is characterised in his book on "England's Neglect of Science," 1901. He possibly adapted his writing too much to the particular case. But he was always original and to the point, and, partly on account of his heterodoxy, he was an excellent man to open a discussion, especially on general subjects like education, in which speakers are apt to lose themselves in repetitions and generalities. Anybody about to follow Professor Perry could rely upon finding points for comment in Perry's address. In 1913 the British Government selected him to proceed to South Africa to draw up a scheme for the foundation of a South African University under the Beit bequest; this scheme was adopted practically as drawn up. He had been in Africa in connection with the British Association meeting of 1905, and he also went to Australia with the Association in 1914. We commented upon his remarkable address delivered in Sydney as president of the Educational Section in our issue of September 14, 1914. He was to be treasurer again at the Cardiff meeting a few weeks hence, and news that the University of South Wales had conferred a science degree upon him only reached him a few hours before his death, which took place last Wednesday afternoon.

The war had not spared him any more than other eminent scientists. His last direct contribution to our columns, a letter on "Cheap and Rapid Gun-Making" (ENGINEERING, March 12, 1915, page 306), dealt with the making of guns out of one piece put under initial stress, and referred to experiments conducted at Elswick before the war. But his advice was frequently sought during the war, and in his leisure hours he followed up his old hobby for spinning tops in working out the problems of gyrostatic compasses together with Mr. Sydney Brown, F.R.S. His health failing, Professor Perry took a three months' sea trip last spring, from which he returned in June hardly the better. His wife, daughter of the late Mr. Thomas Jowitt, of Sheffield, had died in 1904, and he leaves no children. A funeral service is to be held at St. Peter's Church, Bayswater, at noon to-morrow, Saturday; the interment is to follow at Wendover Churchyard at 2.15.

THE EFFICIENCY OF PROPULSION OF FULL-SIZED SHIPS.*

By C. Frodsham Holt, M.Eng., Associate Member.

1. *The Use of Model Propeller Experimental Results.*—In the published works of Mr. R. E. Froude and of Admiral Taylor are to be found sufficient data on the performance of model propellers to cover the whole field of ordinary ship design, with the exception of the fastest types of destroyers and cruisers. But it is not possible to use these results directly in design because of the differences known to exist between the behaviour of a model propeller working in open water and that of a full-sized propeller working in the disturbed wake immediately behind a ship;† in addition, it is possible that the law of mechanical similitude does not hold exactly. The complex propulsive coefficient deduced from ordinary steam trials cannot be resolved into its elements for lack of sufficient data, so that there is no basis for comparing the efficiency of full-sized propellers. performed on the T.S.S. Oyapock, a vessel built by the above firm some thirteen years ago, and communicated to the Transactions by Mr. J. Hamilton Gibson, O.B.E.,* after a discussion. The author has analysed both these trials, and has been enabled to assess the values of the several elements of the efficiency of propulsion, and thus to compare the performance of full-sized propellers with that of models. It is thought that the method of analysis used can be adapted to the treatment of ordinary steam trials where the thrust of the propellers is not measured. The results of such analysis can then be applied to new designs, and will, in addition, lend more flexibility, and perhaps more certainty, to the value of propulsive coefficients used in estimating horse-power.

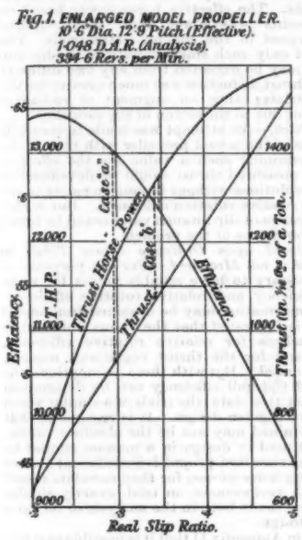
3. *Trials of the Mackay, Oyapock and Javary.*—The Mackay is a flotilla leader of the "Scott" class, the leading particulars of which were given to this Institution in a paper last year.† She was fitted with two three-bladed manganese bronze propellers, of which unfortunately, the value of the analysis disc area ratio (1·048) fell beyond the limits of Mr. Froude's experiments, The twin-screw steamers Oyapock and Javary were built about thirteen years ago for service on the Amazon. Their leading dimensions were :—

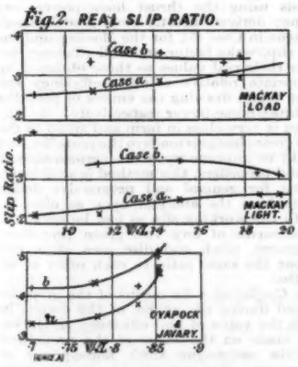
Length between perpendiculars 243 ft., breadth 36 ft.

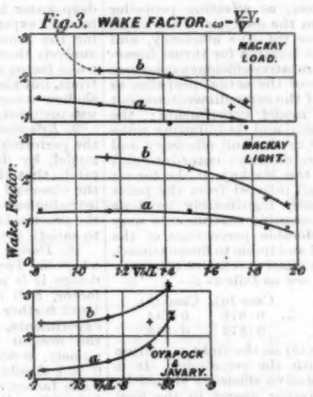
Draught on trial :
Oyapock, mean 7 ft. 9½ in., aft 8 ft. 4½ in.
Javary, mean 8 ft., aft 8 ft. 1 in.

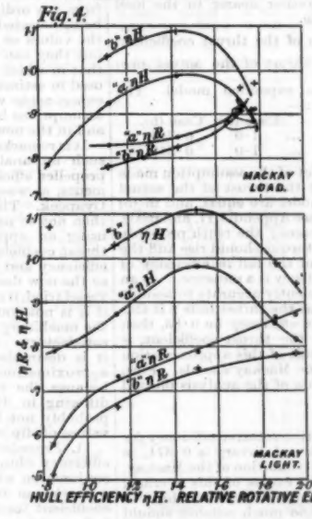
Displacement :
Oyapock, 1,290 tons.
Javary, 1,326 tons.

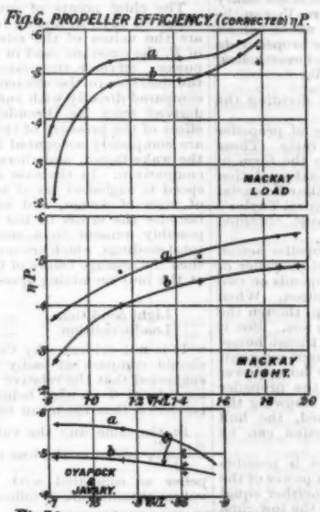
Their propellers, having three elliptical manganese bronze blades, were each 7 ft. 6 in. in diameter and of 25 sq. ft. developed area; those of the Oyapock had a face pitch of 11 ft., of the Javary 12 ft. These propellers, being restricted in diameter, and working at an abnormally high slip ratio, were very inefficient; this fact, however, does not affect the value of the analysis, because we seek the relative rotative efficiency: the

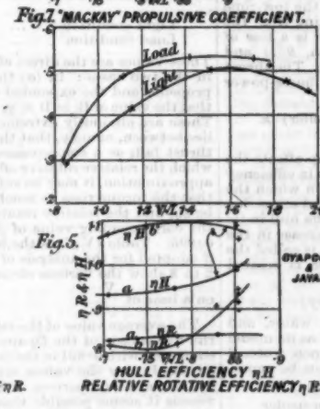


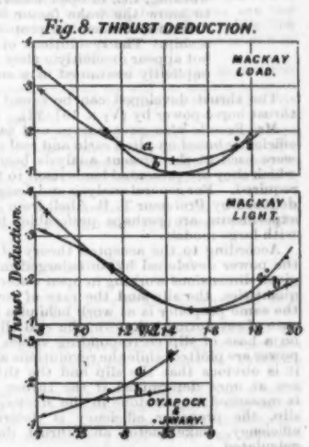


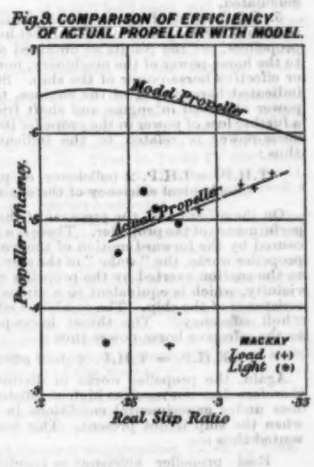












Nevertheless, it is fully evident that the propulsive coefficient derived synthetically from model experiments is not realised in the actual ship; but to which of the elements—propeller efficiency, wake factor, or hull efficiency—the loss is due is not known; indeed, it is probable that none of these is the same in the ship as in the model. For this reason the powering of ships, notwithstanding the great advances that have been made in the study of the resistance side of the problem, is still hedged about with difficulties and pitfalls; large margins of power must be provided to cover possibilities of error.

2. *Measurement of Thrust of Propellers.*—A step forward has recently been taken, which, while not sufficient in itself to reach a secure basis for future designs, at least gives a lead in the direction along which progress will be made. During the progressive trials of H.M.S. Mackay, a flotilla leader of the "Scott" class built by Messrs. Cammell Laird and Co., Limited, the actual thrust of each propeller was accurately measured and recorded for a wide range of speed and power. The results of these trials were published in Engineering last August. Such measurements have doubtless been made before (Sir A. Denny has referred to some such experiments‡); but the only extensive experiments known to the author as having been made public are those and it was necessary to extrapolate to obtain values for B and propeller efficiency. But it is thought that, from the regular nature of Mr. Froude's curves, any error due to this cause will not exceed a comparatively small amount.

Complete progressive trials were run at two draughts corresponding to the light and deep load conditions. Mean of means based on four or six runs on the measured mile were obtained for speed, revolutions, power and thrust at each of five speeds in both conditions. No attempt was made to fair the recorded values of these quantities before using them in the analysis, as the five groups of observations are separated too widely to justify such an attempt. This fact probably accounts for the inconsistency to be noticed at the middle speed in the light series. The engineers reported a defect in the pump used to maintain the oil pressure in the thrust-measuring device during the runs at this speed. It may also account for the inconsistency at the upper speeds in the load series, though on the other hand this may possibly be due to incipient cavitation.

In estimating E.H.P. the displacement (recorded before and after the trials) was adjusted on the assumption that the rate of consumption of the oil fuel varied directly as the shaft horse-power, and by paying attention to the recorded times at which each mile was run. The results of these trials are given in Appendix I, Table I, page 195, and the elements of the analysis in Tables II, III and IV, on the same page, and Figs. 2 to 8, annexed.

absolute value of the efficiency is taken into account quite separately from this factor.

The thrusts were not measured on all the trials that were run, but on the progressive trials of the Oyapock the thrust of the starboard propeller was obtained, and the mean of means of several runs at each of three speeds are available; while the same was done during two sets of runs at full power on the Javary. The records were taken in the form of indicator diagrams, by an indicator operated from the air-pump lever on the engine, and in hydraulic connection with the thrust block. The device was only fitted to the starboard shaft, but as the indicated horse-power and revolutions of the two engines were almost identical, it is not unjustifiable to estimate the total thrust from that of one propeller.

The shaft horse-power was also recorded by torsion-meter, but it is now thought that no absolute reliance can be placed on the results obtained; no account has been taken of these results in the analysis. It has been assumed that the mechanical efficiency is 0·9 when the indicated horse-power is 1,800, and that at other powers the shaft horse-power is related to the indicated horse-power as follows :—

$$S.H.P. = 0{\cdot}967\ (I.H.P.) - 120$$

The results o fthe trials are given in Table V, page 195, while the elements of the analysis are given in the same form as for the Mackay in Tables VI, VII, and also in Figs. 2 to 8, on the present page.

4. *Basis of Analysis.*—Mr. R. E. Froude gave before this Institution in 1908 a method of estimating the thrust

* Paper read before the Institution of Naval Architects, July 7, 1920.

† Mr. G. S. Baker ("Ship Form Resistance and Screw Propulsion," 1915, pages 161 and 162) says, on the other hand, that there is practically no difference.

‡ Sir A. Denny, Trans. I.N.A., vol. liii, page 146.

* Mr. J. Hamilton Gibson, I.N.A., vol. liii, page 147.

† Sir Eustace Tennyson d'Eyncourt, Trans. I.N.A., vol. lxi, page 75.

horse-power of model propellers.* Professor T. B. Abell in 1910 substantially confirmed this† by comparing it with D. W. Taylor's experiments upon slightly larger propellers. Mr. Froude showed that the thrust horse-power developed by a model propeller working in open water can be expressed in the form.

$$\text{T.H.P.} = y\ B\ D^2\ V_1^3\ \frac{p + 21}{p} \quad . \quad . \quad (1)$$

where y is a function of the real slip, independent of the type or dimensions of the propeller. Its values were presented in a table and also as a curve,

B is independent of slip, but varies with number and shape of blades, and helicoidal disc area ratio (corrected for area of hub),

D is the diameter of the propeller in feet,

p is the ratio of effective pitch (2 per cent. greater than face pitch) to diameter,

V_1 is the speed of advance (in knots) of the propeller relative to the water in which it is working, *i.e.*, in open water. It is necessary to know the wake factor before V_1 can be determined when the propeller works behind a ship. The revolutions of the propeller do not appear explicitly; they are, nevertheless, implicitly contained in y and V_1.

The thrust developed can be found by dividing the thrust horse-power by ($V_1 \times 101 \cdot 33$).

Mr. Froude also gave curves and tables of propeller efficiency based on pitch ratio and real slip ratio. These were used in the present analysis because the form in which they are presented lends itself to the extrapolation required. For general analysis and design, the efficiencies deduced by Professor T. B. Abell from Admiral Taylor's experiments are perhaps preferable, because obtained with large models.

According to the accepted theory of propeller action the power developed by an enlarged model propeller of given dimensions working in open water, depends on two quantities, the slip and the rate of revolution. When the same propeller is at work behind a ship, though the rate of revolution is known, the real slip is not. But if on a base of slip corresponding values of thrust horse-power are plotted while the revolutions are kept constant, it is obvious that the slip and the thrust horse-power are at once determined if the thrust of the propeller is measured as was done in the Mackay. Knowing the slip, the propeller efficiency is determined, the hull efficiency, wake factor and thrust deduction can be calculated.

3. *Efficiency of Propulsion.*—Although it is possible to calculate by equation (1) the thrust horse-power of the propellers, yet the results so obtained are neither equal to the horse-power of the machinery, nor to the tow-rope or effective horse-power of the ship. Starting from the indicated horse-power of the engines, there is a loss of power absorbed in engine and shaft friction, &c.; and a further loss of power in the propeller itself. The thrust horse-power is related to the indicated horse-power thus :—

$$\text{T.H.P.} = \text{I.H.P.} \times (\text{efficiency of propeller}) \times (\text{mechanical efficiency of the engines})$$

On the other hand, the presence of the ship affects the performance of the propeller. There is a gain in efficiency caused by the forward motion of the water in which the propeller works, the "wake" of the ship; and a loss due to the suction exerted by the propeller on the hull in its vicinity, which is equivalent to a virtual increase in the resistance of the ship. The combined effect is called the "hull efficiency." The thrust horse-power is related to the effective horse-power thus :—

$$\text{E.H.P.} = \text{T.H.P.} \times (\text{hull efficiency})$$

Again, the propeller works in disturbed water, and therefore does not reach so high an efficiency as its model does under experimental conditions in "open water," when the ship is not present. This loss can be represented thus :—

$$\text{Real propeller efficiency} = (\text{model propeller efficiency}) \times (\text{relative rotative efficiency})$$

Taking all these factors into consideration the overall efficiency of propulsion, with which the naval architect is chiefly concerned, can be expressed in the form :—

$$\text{Propulsive coefficient} = \frac{\text{E.H.P.}}{\text{I.H.P.}} = (\text{hull efficiency}) \times (\text{model propeller efficiency}) \times (\text{relative rotative efficiency}) \times (\text{mechanical efficiency}).$$

If the propulsive coefficient is based on shaft horse-power the last factor does not enter into the relation. The efficiency of propulsion of the vessels, whose trials are recorded in § 3 and Tables I and V, has been analysed by the method described in Appendix II. The results of this analysis are given in Tables II to IV and VI and VII, and are illustrated graphically in the figures on page 193. The chief points of interest are reviewed in the following paragraphs. The method of analysis consists essentially in plotting curves of thrust horse-power, thrust, and model propeller efficiency on a base of real slip ratio, using values derived from Mr. Froude's propeller experiments. With the trial data available there are two ways of approaching the problem; first as in case (*a*) by working from the point on the diagram (see Fig. 1), where the thrust is equal to that observed in the ship; and secondly from the propulsive coefficient based on an estimate of effective horse-power, and the shaft horse-power actually observed (Case *b*). (See § 13, Appendix II.)

4. *Relative Rotative Efficiency and Thrust Coefficient.*—Now if the actual propeller gave the same performance as the model, these two methods would lead to the same result; the effect of the presence of the ship would be completely represented by the hull efficiency, and the relative rotative efficiency would be 100 per cent. But they do not agree, as Tables II and III, VI and VII show. The relative rotative efficiency is of the order of 85 per cent.; and further, the two methods of attack lead to different values of relative rotative efficiency, slip ratio, and wake factor (see Fig. 1). The meaning of this fact is that the efficiency of the propeller working behind the real ship is only of the order of 85 per cent. of that of a similar model propeller, working in open water. This the analysis shows very definitely. But there is nothing to indicate whether the loss is due to increase in torque or decrease in thrust; the propulsive coefficient is the same whichever method is used, the difference being made up by an alteration in the slip and wake factor obtained during the analysis.

The chief points of interest, as affecting propeller design in general, arising from the analysis of the trials are the values of the relative rotative efficiency, and of B, the constant used in the formula for thrust horse-power. Of these, the relative rotative efficiency measures the decrease in the efficiency of the actual propeller as compared directly with one of the same dimensions, but derived from Mr. Froude's model experiments; the effect of the presence of the ship and its following wake are completely accounted for in the hull efficiency and the wake factor, and therefore does not enter into this comparison. In the case of the Mackay, if the lowest speed is neglected (as of small interest from the point of view of design, and as may legitimately be done because the errors in the measuring instruments may possibly amount to a considerable percentage of the total readings, which are small and liable to fluctuations), then the average values of the relative rotative efficiency at the four remaining speeds are as follows :—

	Case (*a*).	Case (*b*).
Light condition	0·816	0·744
Load condition	0·873	0·849

It is not evident why Case (*b*) in the light condition should compare so badly with the remainder. It is suggested that the relative rotative efficiency should be considered 0·85, this being rather nearer to the load condition than the mean value.

In the same way the value of the thrust coefficient, $\beta = \frac{B^1}{B}$, measures the loss in thrust of the actual propeller as compared with an expanded model. The values obtained are as follows :—

	Case (*a*).	Case (*b*).
Light condition	1·0	0·744
Load condition	1·0	0·849

These values are the direct effect of the assumption made in the two cases: In (*a*) that the thrust of the actual propeller and the expanded model are equal, and in (*b*) that the value of $B_1 = B \times \eta_R$ (see Appendix II, annexed). These are obviously extreme cases; the truth probably lies between, namely, that the torque should rise and the thrust fall, as a consequence of the fall in efficiency of which the relative rotative efficiency is a measure. As an approximation, it may be sufficiently accurate to assume that the torque rises as much as the thrust falls; if this be so, and the relative rotative efficiency be 0·85, then the corresponding value of β, the thrust coefficient, is 0·925. Table IV gives the result of this approximation if adopted for the analysis of the Mackay's trials. Figs. 2 to 8 show the various elements of the analysis plotted on a base of $\frac{V}{\sqrt{L}}$.

The average value of the relative rotative efficiency for the five speeds of the Oyapock and Javary is 0·871, as compared with 0·861 in the load condition of the Mackay. In the Javary the values are in excess of this average, but from a comparison with other trials of the two vessels it seems possible that too much reliance should not be placed on these particular figures.

Thus, although the trials of the Oyapock and Javary are neither so comprehensive nor so completely reliable as those of the Mackay, yet the results obtained serve in some measure to confirm the conclusion arrived at, namely, that a safe working figure for relative rotative efficiency is about 85 per cent.

7. *Real Propeller Efficiency.*—The real propeller efficiency can be expressed as (model propeller efficiency) × (relative rotative efficiency), as was noticed in § 5. This quantity is shown in Fig. 9 plotted on a base of real slip ratio, for the Mackay; and the efficiency of an enlarged model propeller of the same dimensions is also shown on the same base for comparison. The range of slip is small, but the shape of the mean curve suggests that the maximum efficiency of the real propeller occurs at a higher slip ratio than that of the model. It is possible that better results would follow from the use of higher slip ratios than model experiments lead us to expect.

8. *Hull Efficiency, Wake Factor and Thrust Deduction.*—The values of hull efficiency found are of the same order as those commonly accepted. These may be affected by errors in estimating effective horse-power; but as is pointed out in Appendix II, this does not alter the slip and wake factors resulting from the analysis.

Wake Factor has been determined from the results of a number of trials by the method of analysis given in § 10. For vessels of medium form, the wake factor agrees with those given by Mr. Luke, but for fine vessels it was appreciably higher and for full vessels appreciably lower. The sudden fall in the Mackay's wake factor at high speeds can be completely accounted for by the fact that a hollow in her transverse wave system then approaches the propellers, the orbital motion tending to neutralise the forward motion of the following wake. It would appear that if it had been practicable to place the propellers a short distance further aft, an appreciable gain in propulsive efficiency would have been the result. In the case of the U.S. destroyer Nicholson and several sister ships, the curve of wake factor on a base of speed, exhibited when analysed as described in § 10 similar results to the Mackay's, but a negative value was obtained at full speed in all the ships.

Thrust Deduction.—This is not the simple quantity determined in ordinary model experiments. The term is only legitimately applicable to the augment of resistance due to the working of the propeller in close proximity to the hull. As used in the present analysis and the method of design suggested in § 10 it probably takes into account errors in estimating effective horse-power. This was very well brought out in the analysis of the trials of a vessel which was run first in the shallow waters off the Mersey, and then on the mile at Skelmorlie. There was a marked increase in the propulsive coefficient in the deep-water trials. The effective horse-power based on model experiments was lower than that required for the same speed in the shallow-water trials. The analysis showed only such small variations in slip and wake factor as may be expected from any two different trials, but the thrust deduction was much greater for the shallow-water trials; thus an augment of resistance was included, not due to the action of the propeller.

9. *Effective Pitch.*—An attempt was made to reconcile the performance of the actual propeller with that of the model, by determining such a value for the effective pitch, that the measured thrust would be developed at the observed revolutions without having to resort to the introduction of relative rotative efficiency. But within the practicable range of slip no such value could be found to satisfy the conditions of the problem.

10. *Design Based upon Ordinary Steam Trials at which the Thrust is not Measured.*—For the purposes of design it is necessary to have reliable values for wake factor, hull efficiency and relative rotative efficiency. Until further confirmation may be obtained from direct experiments, it is suggested that the values obtained in the present analysis for relative rotative efficiency, namely, 0·85, and for the thrust coefficient, namely, 0·925, should be used. But with these assumptions, the wake factor and the hull efficiency can be determined from any ordinary trial data, the trials of a similar vessel being selected for a given design. It is recognised that the values so obtained may not be the absolute values, but they can be used in design in a manner similar to that in which the standard propulsive coefficient is now used in estimating horse-power, for they correlate model experiments with performance on trial, exactly similar assumptions being made both in the analysis of the trial and in the new design.

It is remarked in Appendix II that it is possible to make such an analysis using the thrust horse-power, and propeller efficiency derived directly from model experiments, as was done in Case (*b*), for the Mackay and the Oyapock. The slip, wake factor and hull efficiency are then not so near their real values as those obtained by using an appropriate relative rotative efficiency and thrust coefficient before drawing the curves of propeller efficiency and thrust horse-power respectively. So long as the new design is very close in form and speed to the vessel tried, if no great change is made in the propeller, and if it is not sought to improve upon the performance of the machinery and propellers, this method is sufficiently satisfactory. But for general and progressive design it is desirable to base the analysis upon as close an approximation to the working slip as can be obtained, because the efficiencies of any two given propellers, differing in diameter, pitch and disc area ratio, will probably not bear the same ratio to each other at all values of slip ratio.

11. *Propulsive Coefficient.*—By means of the propeller efficiency obtained during the course of the design, in conjunction with the value of hull efficiency employed, a check can be made on the value of the propulsive coefficient used in estimating shaft horse-power or indicated horse-power. For example, in a certain case, during the preliminary stages of the design, the shaft horse-power had been based on the performance of a ship already in service for the same owners; the propulsive coefficient, in terms of shaft horse-power, was 0·456. After designing the propellers, it was found possible to expect a hull efficiency of 0·95 from the analysis of similar ships, and a propeller efficiency of 0·62, giving a propulsive coefficient of 0·589; allowing 14 per cent. for appendages, this becomes 0·506, as compared with 0·456 originally assumed. The reduction in shaft horse-power is over 10 per cent.

In conclusion, the author wishes to acknowledge the courtesy of Messrs. Cammell Laird and Co., Limited, in having placed at his disposal the data on which his work is based. His thanks are also due to Mr. A. T. Wall, O.B.E., A.R.C.S., for his advice and criticism both during the work and its preparation as a paper.

APPENDIX II.

Method of Analysis.

12. *Method of Analysis.*—If the revolutions per minute R are given, then for any selected value of slip ratio s :—

$$V_1 = 1 - s\ \frac{RP}{101 \cdot 33}$$

where P is the effective pitch = 1·02 × face pitch.

For a suitable range of s, values of V_1 were calculated and, together with the appropriate values of y, were used to evaluate thrust horse-power by formula (1), and also the thrust. Thus, for each mean of means of revolutions

* Trans. I.N.A., vol. l., "Results of Further Model Screw Propeller Experiments," by Mr. R. E. Froude.

† Trans. I.N.A., vol. lii, "Model Screw Propeller Results; a Comparison," by Professor T. B. Abell.

APPENDIX I.

TABLE I.—Trial Results of "Mackay." (Mean of Means.)

—	Light Condition.					Load Condition.				
	A	B	C	D	E	F	G	H	K	L
Speed (knots)	35·46	33·77	27·46	20·83	15·42	32·40	31·19	25·88	20·29	15·25
Revolutions per minute (mean)	353·4	331·4	258·3	186·9	136·3	334·6	320·1	252·5	189·7	138·1
Shaft horse-power (total)	44,530	38,200	19,460	7,300	3,560	42,250	36,610	18,920	7,620	4,066
Thrust (total) in 1/10ths of a ton	1,651	1,516	960	441	228	1,849	1,751	1,029	530	270
E.H.P. (estimated) including appendages	20,140	18,330	9,780	3,028	1,056	21,440	19,250	9,880	3,785	1,220
Propulsive coefficient	0·452	0·472	0·5	0·415	0·297	0·508	0·525	0·53	0·49	0·3

TABLE II.—"Mackay"—Results of Analysis by Method (*a*).

	Light Condition.					Load Condition.				
	A	B	C	D	E	F	G	H	K	L
s	0·209	0·264	0·257	0·225	0·221	0·297	0·308	0·287	0·266	0·257
w	0·083	0·088	0·121	0·123	0·125	0·087	0·167	0·095	0·138	0·152
t	0·253	0·222	0·136	0·232	0·308	0·167	0·18	0·104	0·205	0·333
η_H	0·814	0·854	0·983	0·875	0·791	0·912	0·919	0·990	0·922	0·787
η_P	0·556	0·554	0·509	0·475	0·375	0·556	0·571	0·535	0·531	0·382
η_R	0·873	0·865	0·792	0·733	0·579	0·889	0·921	0·85	0·832	0·594
β	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0
Model propeller efficiency	0·637	0·64	0·642	0·648	0·648	0·626	0·62	0·63	0·639	0·642

TABLE III.—"Mackay" Results of Analysis by Method (*b*).

—	Light Condition.					Load Condition.				
	A	B	C	D	E	F	G	H	K	L
s	0·311	0·317	0·343	0·337	0·403	0·342	0·329	0·352	0·333	0·447
w	0·136	0·153	0·223	0·251	0·397	0·146	0·133	0·204	0·217	0·48
t	0·19	0·163	0·137	0·227	0·352	0·171	0·167	0·136	0·191	0·286
η_H	0·989	0·937	1·111	1·032	1·075	0·97	0·981	1·086	1·032	1·371
η_P	0·482	0·477	0·45	0·401	0·277	0·524	0·546	0·488	0·475	0·218
η_R	0·779	0·777	0·753	0·668	0·508	0·875	0·910	0·825	0·785	0·434
β	0·779	0·777	0·753	0·668	0·508	0·875	0·910	0·825	0·785	0·434
Model propeller efficiency	0·619	0·614	0·598	0·601	0·546	0·598	0·6	0·592	0·605	0·503

TABLE IV.—"Mackay"—Final Results of Analysis. Thrust Coefficient $\beta = 0.925$.

—	Light Condition.					Load Condition.				
	A	B	C	D	E	F	G	H	K	L
s	0·259	0·286	0·278	0·243	0·237	0·322	0·331	0·314	0·29	0·272
w	0·072	0·093	0·145	0·148	0·152	0·119	0·136	0·157	0·166	0·172
t	0·215	0·166	0·138	0·233	0·303	0·167	0·181	0·127	0·206	0·31
η_H	0·847	0·92	1·008	0·898	0·823	0·945	0·948	1·023	0·952	0·833
η_P	0·534	0·513	0·496	0·462	0·361	0·538	0·554	0·542	0·515	0·36
η_R	0·833	0·804	0·783	0·715	0·558	0·88	0·914	0·88	0·819	0·565
Model propeller efficiency	0·641	0·638	0·634	0·646	0·647	0·611	0·606	0·616	0·629	0·637

TABLE V.—*Trial Results of "Oyapock" and "Javary."*

—	"Oyapock."			"Javary."	
	A	B	C	D	E
Speed (in knots)	11·01	12·22	12·92	13·30	13·32
Revolutions per minute (mean)	132·2	147·6	156·1	152·1	152·6
Indicated horse-power (total)	880	1,236	1,424	1,898	1,875
Thrust in pounds for starboard shaft	7,060	9,100	10,850	13,750	13,388
E.H.P. (estimated) including appendages	395·3	569·5	725·7	844·9	850·4
Assumed mechanical efficiency	0·832	0·87	0·883	0·903	0·902
Propulsive coefficient on shaft horse-power	0·53	0·529	0·577	0·496	0·503

TABLE VI.—"*Oyapock*" *and* "*Javary*." *Results of Analysis by Method* (*a*).

—	A	B	C	D	E
s	0·338	0·358	0·383	0·462	0·47
w	0·12	0·142	0·175	0·257	0·246
t	0·125	0·185	0·114	0·261	0·27
η_H	0·938	0·95	1·072	0·996	0·994
η_P	0·564	0·556	0·538	0·496	0·506
η_R	0·828	0·835	0·838	0·897	0·93
β	1·0	1·0	1·0	1·0	1·0
Model propeller efficiency	0·682	0·666	0·642	0·554	0·543

for a group of runs on the mile, three curves (see Fig. 10) were drawn on a base of real slip ratio s; the thrust horse-power, the thrust, and the efficiency. Each set of curves refers to a given constant rate of revolution of the given propeller, while V_1, and therefore, implicitly, the wake factor, vary from point to point (see Fig. 1). A typical example is given in full in § 14.

Now, the following data are known from the results of the trials:—

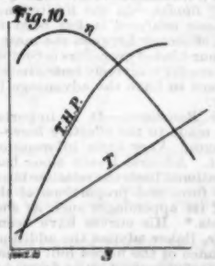
TABLE VII.—"*Oyapock*" *and* "*Javary*." *Results of Analysis by Method* (*b*).

—	A	B	C	D	E
s	0·417	0·433	0·425	0·506	0·502
w	0·225	0·242	0·232	0·317	0·312
t	0·169	0·168	0·178	0·258	0·271
η_H	1·072	1·098	1·07	1·087	1·058
η_P	0·493	0·482	0·541	0·456	0·475
η_R	0·814	0·818	0·904	0·914	0·94
β	0·814	0·818	0·904	0·914	0·94
Model propeller efficiency	0·606	0·59	0·598	0·499	0·506

Speed of ship, in knots (V),
Revolutions of propeller per minute (R),
Shaft horse-power (S.H.P.),
Measured thrust in 1/10ths of a ton (T_m),

and the effective horse-power (E.H.P.) was estimated from model experiments, an addition being made for appendage resistance; the propulsive coefficient was evaluated.

Fig. 10.



From these data by means of the above curves it is possible to obtain:—

The real slip ratio (s),
Relative rotative efficiency (η_R),
Hull efficiency (η_H),
Real propeller efficiency (η_P),

Wake factor $\left(w = \frac{V - V_1}{V}\right)$.

The curves in Fig. 1 hold for an enlarged model propeller, of dimensions equal to the actual ship's propeller, working in "open water"—that is, not in the presence of the ship. In the real ship there is only one value of s for which the observed horse-power and thrust are developed at these revolutions; it is the object of the analysis to discover this value of s. It was found that different results are obtained according as the horse-power or the thrust is used as a basis; these may be regarded as the two extreme cases between which the truth must be sought.

(*a*) There is the possibility that the thrust of the full-sized propeller and its thrust horse-power are the same as those for the enlarged model propeller, while the propeller efficiency is in defect and the shaft horse-power in excess. The results of the analysis based on this assumption are given in Table II and Figs. 2 to 8, and the procedure is explained and illustrated by a typical example in § 15.

(*b*) Again, there is the possiblity that the torque of the full-sized propeller and its shaft horse-power are the same as for the enlarged model propeller, while the propeller efficiency and the thrust horse-power are in defect (see Table III and § 16).

Method (*a*) can only be applied when the thrust has actually been measured, but as will be shown later, a modification of method (*b*) can be adapted to the analysis of ordinary trial results.

An examination of Tables II and III revealed that considerable and regular differences result from the two methods of analysis. It therefore became necessary to find some common basis of comparison before attempting to assign a meaning to them.

13. *The Basis of Comparison.*—For this purpose a further analysis was made on a slightly different principle. We have from (1)—

$$\text{T.H.P.} = y\,B\,D^2V_1^3\,\frac{P \times 21}{P}$$

but also $\text{T.H.P.} = T_m \times V_1 \times 0{\cdot}43$, where 0·43 is a constant for adjusting the units.

Equating these, it is possible for a given range of V_1, *i.e.*, of slip ratio, and for given thrust T_m, to calculate values of $y \times B$, the empirical constant in Froude's formula.

In this manner, from the trial values of T_m, a series of curves of $y \times B$ were plotted on a base of slip ratio; as, however, there was not sufficient data to distinguish between the two constants y and B, it was assumed that Froude's value of y still held good, and curves of B only plotted on a base of slip. If any particular value of B is selected, the value of the slip at which the thrust T_m is developed by the propeller is fixed for each trial run; and all the elements of the analysis follow immediately.

Thus, if we assume $B = 0{\cdot}12$ (as given by Froude for the Mackay's propeller), we get case (*a*) above. Again, if we assume $B = 0{\cdot}12 \times \eta_R$, we get case (*b*) above. It is possible to investigate intermediate cases by assuming suitable values of B. Thus, in Table IV the effects of the assumption that $B_1 = 0{\cdot}12 \times 0{\cdot}925 = 0{\cdot}111$, are given in full. It appears convenient to name such a factor as 0·925 the "thrust coefficient" (β).

It now remains to examine the result of applying these methods to the analysis of the trials of the Mackay and of the sister ships Oyapock and Javary.

14. The first step in the analysis is to plot at each of the observed speeds sets of three curves—the thrust horse-power, the thrust and the propeller efficiency on a base of slip as in Fig. 1, using for each set the appropriate observed value of mean revolutions. This is done by the use of Mr. Froude's formula quoted in the text (see § 4); the following is a typical example, the upper speed in the load condition of the Mackay:—

Speed of ship, V = 32·40 knots.
Revolutions per minute, R = 334·6.
Total shaft horse-power = 42,250.
Measured thrust of one propeller, $T_m = \frac{925}{16}$ tons.
Propeller, three-bladed manganese bronze.
Diameter, 10·5 ft.
Face pitch 12·5 ft., effective pitch 12·75 ft.
Pitch ratio 1·215.
Developed area 72·5 sq. ft.
Disc area ratio for analysis 1·048.

$$B = 0{\cdot}12.$$

$$\text{T.H.P.} = y\,V_1^3 \times 10{\cdot}5^2 \times 0{\cdot}12 \times \frac{22{\cdot}215}{1{\cdot}215}$$

and

$$V_1 = (1 - s) \times \frac{334{\cdot}6 \times 12{\cdot}75}{101{\cdot}33}.$$

s.	y.	V_1 (Knots)	T.H.P.	T (Tons ×16).	η_r.
0·2	0·000989	23·63	9,100	630	0·642
0·3	0·001922	29·42	11,820	985	0·634
0·4	0·003457	25·22	13,390	1,235	0·549
0·5	0·006175	21·02	13,840	1,532	0·445

These curves are given in Fig. 1.

It is found that the model results as developed by this means do not satisfy the conditions of the problem, for the propulsive coefficient as obtained in the form $\frac{\text{E.H.P.}}{\text{S.H.P.}}$ is not equal to that obtained in the form $\eta_r \times \eta_h$. Indeed, two values of slip ratio are obtained according as one assumes that the model thrust equals the actual

measured thrust, or that the model shaft horse-power equals the actual shaft horse-power.

15. *Case* (*a*).—Method of analysis when model thrust is assumed equal to the thrust actually developed on trial.

A point is found on the curve of thrust T, where $T = T_m$, the observed thrust of the propellers on trial. At the same value of slip ratio the thrust horse-power and propeller efficiency η_P are lifted. Then :

$$V_1 = (1 - s)\ \frac{R\,P}{101{\cdot}33}$$

and wake factor :

$$w = \frac{V - V_1}{V}$$

where V is the mean speed of ship.

$$\text{The propulsive coefficient} = \frac{\text{E.H.P.}}{\text{S.H.P.}} = \eta_P \times \eta_H \times \eta_R.$$

where

η_H = hull efficiency,
η_R = relative rotative efficiency.

Of these quantities E.H.P., S.H.P. and η_P are already known, and

$$\eta_H = \frac{\text{E.H.P.}}{\text{T.H.P.}}$$

Hence η_R can be evaluated in the form :

$$\eta_R = \frac{\text{Propulsive coefficient}}{\eta_H \times \eta_P}$$

The net or "real" propeller efficiency is $\eta_P \times \eta_R$. The analysis is complete when the thrust deduction t has been evaluated, for :—

$$\frac{1 - t}{1 - w} = \eta_H$$

The following example refers to the curves already illustrated in Fig. 1.

The model propeller develops a thrust of $\frac{925}{T_m}$ tons when working at a real slip ratio 0·297.

At this slip ratio, lifting from the curves :

$$\text{T.H.P.} = 23{,}520 \text{ (2 propellers)}$$
$$\eta_P = 0{\cdot}626$$

Then

$$V_1 = (1 - 0{\cdot}297) \times 42 = 29{\cdot}5 \text{ knots}$$

$$w = \frac{32{\cdot}4 - 29{\cdot}5}{32{\cdot}4} = 0{\cdot}087$$

$$\text{Propulsive coefficient} = \frac{21{,}440}{42{,}250} = 0{\cdot}508$$

$$\eta_H = \frac{21{,}440}{23{,}520} = 0{\cdot}912$$

$$\eta_R = \frac{0{\cdot}508}{0{\cdot}626 \times 0{\cdot}912} = 0{\cdot}889$$

$$\text{Corrected propeller efficiency} = 0{\cdot}626 \times 0{\cdot}912 = 0{\cdot}571$$

$$1 - t = 0{\cdot}912\ (1 - 0{\cdot}087)$$
$$t = 0{\cdot}167$$

16. *Case* (*b*).—Method of analysis when model shaft horse-power is assumed equal to shaft horse-power actually developed on trial.

In this case the analysis is not so direct, but the method can be applied to ordinary trial results.

Starting from the known values of E.H.P. and S.H.P. the propulsive coefficient, p.c. $= \frac{\text{E.H.P.}}{\text{S.H.P.}}$

Then working from the curves of η_P and T.H.P. by successive approximation, a value of slip ratio is sought at which the following identity holds :—

$$\eta'_H = \frac{\text{E.H.P.}}{\text{T.H.P.}} = \frac{\text{Propulsive coefficient}}{\eta_P}$$

The value of η'_H so found is not what may be called the "real" hull efficiency, which is defined by the relation

$$\eta_H = \frac{1 - t}{1 - w},$$

the relative rotative efficiency is included in the value of η'_H so found. But because η_R is also included in an exactly similar manner on both sides of the identity, the error does not extend to or invalidate the slip ratio as determined by this method.

Having thus determined real slip ratio, and η'_H, the following quantities can be either lifted directly from the curves or evaluated as in case (*a*), namely : Slip ratio s, (T.H.P.)′ model thrust T, V_1, wake factor w, apparent hull efficiency η'_H, and apparent propeller efficiency, the two latter quantities including η_R yet to be determined. Now the thrust T so obtained does not agree with that measured on trial T_m ; and since by hypothesis the S.H.P. does so it necessarily follows that the ratio $\frac{T_m}{T}$ gives η_R, the relative rotative efficiency.

Thus the apparent values of (T.H.P.)′ and η'_P must be reduced in this ratio giving :—

$$\text{T.H.P.} = (\text{T.H.P.})' \times \eta_R$$
$$\eta_P = \eta'_P \times \eta_R$$

The "real" hull efficiency is obtained from :

$$\eta_H = \frac{\text{propulsive coefficient}}{\eta_P}$$

Table III gives the results of the Mackay's trials analysed by this method. The following example refers to the curves already illustrated in Fig. 1.

It is known that E.H.P. = 21,440
p.c. = 0·508

As a first approximation assume $\eta_R = 0{\cdot}845$. Then for two propellers :

$$(\text{T.H.P.})' = \frac{21{,}440}{0{\cdot}845} = 25{,}380$$

for one propeller, 12,690.

From the curves $\eta_P = 0{\cdot}595$. Then

$$\eta'_H = \frac{0{\cdot}508}{0{\cdot}595} = 0{\cdot}854$$

but 0·845 was assumed.

As a second approximation assume $\eta'_H = 0{\cdot}849$. Then

$$(\text{T.H.P.})' = \frac{21{,}440}{0{\cdot}849} = 25{,}280$$

for one propeller, 12,640. When

$$\eta_P = 0{\cdot}598.$$

Then

$$\eta'_H = \frac{0{\cdot}508}{0{\cdot}598} = 0{\cdot}849 \text{ as required.}$$

This occurs when $s = 0{\cdot}342$ and T = 1,060 for one propeller.

Proceeding as in case (*a*), $w = 0{\cdot}146$.

Now measured thrust = 925 for one propeller. Then

$$\eta_R = \frac{T_m}{T} = \frac{925}{1{,}060} = 0{\cdot}875$$

Then

$$\text{corrected } \eta_H = \frac{0{\cdot}849}{0{\cdot}875} = 0{\cdot}97$$

$$\text{corrected } \eta_P = 0{\cdot}598 \times 0{\cdot}875 = 0{\cdot}524.$$
$$\text{corrected T.H.P.} = 25{,}280 \times 0{\cdot}875 = 22{,}120 \text{ and}$$

$$\frac{1 - t}{1 - 0{\cdot}146} = 0{\cdot}97$$

or

$$= 0{\cdot}171$$

APPENDIX III.

Design Based on Ordinary Steam Trials at which the Thrust is not Measured.

17. *Analysis of Trials : Procedure suggested.*—Curves of thrust horse-power and propeller efficiency are plotted on a base of real slip ratio, making the ordinates of the former 0·925, and of the latter 0·85, of those obtained from available published results of model propeller experiments.

A point is then found by trial and error such that the hull efficiency as determined in the form $\frac{\text{E.H.P.}}{\text{T.H.P.}}$ is equal to that given by $\frac{\text{propulsive coefficient.}}{\text{propeller efficiency}}$. The hull efficiency is one of the quantities it is desired to obtain ; from the slip ratio at which this identity occurs the wake factor follows, for :

$$V_1 = (1 - s) \times \frac{R\,P}{101{\cdot}33}$$

and

$$w = \frac{V - V_1}{V}$$

Given the effective horse-power, the analysis can easily be completed in half an hour.

18. *Design.*—Having obtained from analysis of trials suitable values for wake factor and hull efficiency, the thrust horse-power required can be estimated from the effective horse-power (including an allowance for appendages) by means of the hull efficiency.

It is then possible to explore the performance of the propellers through a suitable range of diameter, pitch and area, by means of cross-curves based on Mr. Froude's thrust horse-power formula already quoted, using a thrust coefficient of 0·925. The method of design originated by Professor T. B. Abell in his 1910 paper (to which the reader is referred) is eminently suited to this purpose.

In selecting from these curves the most suitable propeller, that giving the best efficiency while still conforming with restrictions on diameter and area is chosen.

If suitable data are to hand for wake factor and hull efficiency, the calculations on which the selection of the most suitable propeller are based, can be carried out in the course of a morning's work.

Number of Blades.—In the limited number of cases that have been analysed it has been found that the difference in efficiency between the most suitable three-bladed and four-bladed propellers is comparatively small. Unless the diameter is severely restricted the three-bladed propeller seems to have the advantage by 1½ per cent. or 2 per cent.

Appendage Resistance.—It is important that some addition, be made to the effective horse-power to allow for appendages. Very little information is available on this point. Admiral Dyson alone has attempted to reduce to a rational basis the relationship that must exist between the form and proportions of the slip and the resistance of its appendages such as shell, rudder and shaft brackets.* His curves have been used for this purpose. Mr. Baker advises the addition of 8 per cent. to the resistance of the naked hull ;† the addition for a large number of vessels derived from Admiral Dyson's curves varied from 11 per cent. to 14 per cent.

* Captain C. W. Dyson, "Screw Propellers," vol. ii, sheet 18.

† Mr. G. S. Baker, "Ship Form Resistance and Screw Propulsion," page 224.

CATALOGUES.

Feed Pumps and Blowers.—The Coppus Engineering and Equipment Company, Worcester, Mass, U.S.A., send a small catalogue relating to their centrifugal feed pump and another explaining their steam turbine blower for undergrate draught ; both are worth attention.

Heating.—A catalogue of patent steam apparatus for heating the atmosphere in industrial buildings, issued by Mr. Irwin C. Wallas, 9, Southampton-street, Bloomsbury-square, London, presents much useful information on the subject and states contract prices for installations.

Sheet Metal Work.—A great variety of tank, cistern, piping and similar work in sheet metal is shown in a catalogue received from Messrs. Thomas Marshall and Son, Armley-road, Leeds. Electric and blowpipe welding and dip galvanising work are done by this firm on a large scale, and also simple and complicated piping work for liquids, engine exhaust, seed conveying, &c.

Locomotives.—The Baldwin Locomotive Works, Philadelphia, U.S.A., send a catalogue describing their system of testing locomotive engines on rollers—a system that allows leaks, hot bearings and other defects to be found. The same firm send a small booklet containing a synopsis of standard specifications of materials for locomotive construction.

Electric Furnaces.—Electric furnaces for heat treatment, including those designed for treating large quantities and long articles, are well represented in the catalogue of Wild-Barfield furnace issued by Automatic and Electric Furnaces, Limited, 281, Grays Inn-road, London, W.C. 1. Quenching and tempering baths and methods of operation are described.

Steam Dryer.—Tompkins's steam dryer is a cast-iron guide, fitted inside the boiler, which causes the steam to strike on spirally-arranged baffle plates on which the moisture is deposited so that dry steam is delivered. The agents are Messrs. Ward and Crichton, 41, Chapel-walks, Liverpool, and Mr. D. Ferguson, 27, Oswald-street, Glasgow.

Mechanical Draught.—The whole subject of mechanical draught in its practical application is lucidly explained and discussed in a booklet issued by the Sturtevant Engineering Company, Limited, 147, Queen Victoria-street, London, E.C. 4. Proper consideration is given to the practical difficulties of regulating heat production to varying requirements and varying weather conditions. Engineers will find the booklet well worthy of perusal.

Electric Motors.—Messrs. Higgs Brothers, Sandpits, Birmingham, who devote their energies entirely to the manufacture of electric motors, have issued a 32-page booklet which forms an abridged list of their products. The list gives brief particulars and mentions prices of the sizes made, distinguishing those always in stock or in progress by heavy type. It should prove very useful for quick reference.

Moulding Boxes.—Moulding boxes made of pressed steel with stiffening ribs are being manufactured by the Incandescent Heat Company, Limited, Smethwick, Birmingham, who offer to make up and despatch any size immediately. The catalogue gives illustrations and a table of prices. Welded joints are not used, and great stiffness and lightness is claimed. The boxes are stated to be specially suitable for machine moulding.

Electric Switchboards.—A new edition of their switchboard catalogue has been issued by the General Electric Company, Limited, 67, Queen Victoria-street, London, E.C. 4. The catalogue gives very full and clear descriptive matter with many illustrations and carefully tabulated particulars of sizes, capacities, &c. Detail parts such as may be required for replacements and extensions are also dealt with.

Water Purification.—A description of a plant for purifying 3,000,000 gallons of water per day is given, with some excellent illustrations, in a booklet issued by the Paterson Engineering Company, Limited, Windsor House, Kingsway, London. The plant, erected for the Birmingham Corporation, includes pumping and purifying machinery with the concrete tanks for treatment. Liquid chloride is used for disinfecting, the method being explained in a small additional pamphlet.

Wind Power Project in Germany.—On the instigation of the *Verein Deutscher Ingenieure*, information was collected last year on the possible general utilisation of wind power. The experts quite recognised that the charging of electric accumulators by windmills could hardly pay. But the suggestion of making the windmills store up water in reservoirs, generally to be utilised in the interest of agriculture and pisciculture unless special conditions justified other uses, found strong support. At the Potsdam Observatory wind velocities of from 2 m. to 16 m. per second have been observed during 99 per cent. of the year, and velocities above 4 m. per second during 92 per cent. Wind speeds of less than 2 m. per second are considered useless, as they will not start the mill wheel ; useful energy hardly becomes available at speeds of less than 4 m. per second, and speeds above 8 m. are again not of any greater value than the lower speeds because they turn the wheel out of the wind direction. The utility of the scheme will largely depend upon the facilities for storing water. A report on the problem was published in Nos. 10 and 11 of the "Mitteilungen des Ausschusses für landwirtschaftliche Fertigung," which is a publication of the German institution referred to.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in Italics.

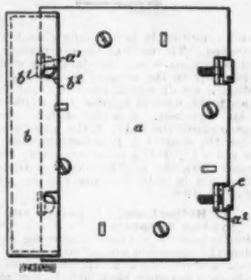
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

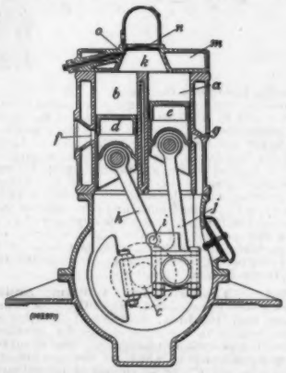
143,069. T. S. Jones, Blackpool, W. A. Mortimer, Blackpool, and E. Jones, Blackpool. Junction Boxes. (2 *Figs.*) June 18, 1919.—The invention relates to junction boxes for electric cables and the novel feature consists in so attaching the cover to the junction-box as to leave the interior of the box quite free of any obstruction. Tail pieces a^1 are formed on one side of the base plate *a* and slots b^1 in the cover *b*. The curved projections a^1 are inserted into the slots b^1 and the cover *b*



is turned over so that as the tail pieces a^1 enter the slots b^1 they are hooked to the base plate *a* and thus secure the cover *b* along one side. On the opposite side the cover *b* is secured by two pinching screws *c* held permanently in position by flaring or riveting their ends. Each pinching screw *c* engages a screw-threaded hole in a bracket a^2 on the baseplate *a*, and as the cover is closed down slots b^2 thereon pass over the heads of the screws *c* and the cover is then securely locked and held in position by tightening up the screws *c*. (*Accepted May* 27, 1920.)

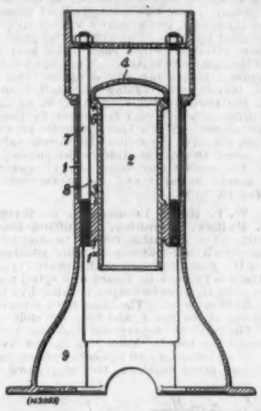
GAS ENGINES, PRODUCERS, HOLDERS, &c.

142,971. W. H. Tate, Manchester, and B. D. Scott, Manchester. Internal-Combustion Engines. (1 *Fig.*) March 18, 1919.—The invention relates to internal-combustion engines of the two-stroke cycle type in which each throw of the crankshaft is connected by connecting rods to two pistons working in duplex cylinders, the one piston having a lead over the other piston, there being a common combustion chamber for the two cylinders, and comprises the arrangement of a hot or unjacketed plate in the common combustion chamber, and of a fuel injector spraying fuel on to this plate at or just prior to the point of maximum compression in the cylinders. The engine cylinders *a*, *b*, are arranged in pairs side by side and with axes at right angles to the axis of the crankshaft *c*, and each throw of the latter is connected to the two pistons *d*, *e*, in each pair of cylinders. One cylinder has the exhaust port *f* therein and the



other cylinder the scavenging air inlet port *g*. One connecting rod A may be fulcrumed about a pin *i* secured upon the end of the other rod *j*. The arrangement provides that the piston *d* reaches the end of the power stroke and uncovers the exhaust port *f* before the piston *e* reaches the end of its stroke and uncovers the scavenging air inlet port *g*, whereby more efficient scavenging of the cylinders is ensured. The scavenging air is obtained from the crank-case in the ordinary manner. There is a common combustion chamber *k* for each pair of cylinders disposed in a detachable head *m*, partly water-jacketed and partly unjacketed to provide a hot plate *n* for the ignition of the fuel charge which is sprayed on to the plate through a fuel injector *o*, receiving its fuel from a pump at or just prior to the point of maximum compression. The fuel is sprayed towards the cylinder containing the air inlet port *g*. (*Accepted May* 27, 1920.)

143,055. J. Weller, Surbiton. Cooling Engine Cylinders. (2 *Figs.*) May 31, 1919.—The invention relates to the cooling of internal-combustion engine cylinders. According to the invention, the cylinders are supported by the bottom of the water jacket which is extended to form one-half of the crank case. The water jacket is in the form of a box open at the top, a hole being bored in the bottom of the box or water jacket to receive each cylinder, which is provided with a flange adapted to be pressed against the bottom of the water jacket, in order to position the cylinder. 1 is the water jacket, 2 the cylinders, which are fitted into the base $1x$ of the water jacket and are provided with flanges 3 which bear against it. 4 is the combustion head which forms



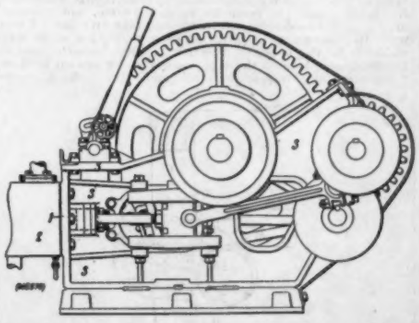
a seal between the top of the cylinders 2 and water jacket 1. The top of the cylinder is provided with a spigot 6 which engages with the combustion head 4. 7 are bolts for holding down the combustion head 4; the bolts 7 pass through the water space 8 and are screwed into the base $1x$ of the water jacket 1. The water jacket is extended to form one-half 9 of the crank-case. (*Accepted May* 27, 1920.)

143,085. P. J. Barker, Coventry, and C. F. Willis, Leicester. Sparking Plugs. (2 *Figs.*) June 30, 1919.—The invention relates to sparking plugs for ignition purposes of the type in which the insulation is extended down to fill in the annular space which separates the central electrode and the body. The novel feature consists in the inner end of the sparking plug being flush and without pockets or projections. Thus the surface of the central electrode exposed to the hot gases is small and its section large, so that little heat is absorbed or retained and the plug can be cleaned by merely being wiped with a rag. A is

the body adapted to screw into the engine, and this is bored out to a taper to receive the tapered insulator B, through which passes the central electrode C. The head D of the electrode is separated from the body A by the annular end B^2 of the insulator B, and the whole inner end of the sparking plug, of which the head D forms a part, is smooth and rounded off. Sparking occurs over the surface of the annular end B^2 and there are no pockets to contain oil or carbon. The sparking end of the central electrode is conical, as at C^2, and the insulator B at the end is correspondingly shaped, so that the tendency is for all joints to tighten up under the explosion pressure. (*Accepted May* 27, 1920.)

LIFTING AND HAULING APPLIANCES.

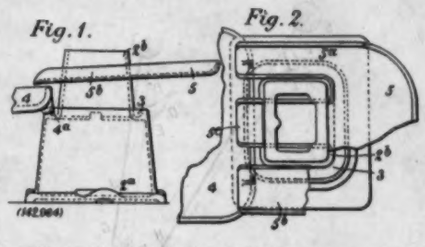
142,676. The Rose Street Foundry and Engineering Company, Limited, Inverness, and S. H. Gordon, Inverness. Steam Winches. (2 *Figs.*) May 26, 1919.—The invention relates to steam winches. According to the invention,



the fore end of each winch cylinder and the adjacent side frame is formed as an integral casting. The fore end 1 of each winch cylinder 2 and the adjacent side frame 3 constitute an integral casting. (*Accepted May* 19, 1920.)

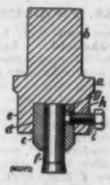
MACHINE AND OTHER TOOLS, SHAFTING, &c.

142,984. A. Smith, Keighley.—Standards for Lathe Beds. (5 *Figs.*) April 4, 1919.—The invention relates to the standards for the beds of lathes. The standard 2 is formed of a tapering character with a comparatively broad base 2a, which gradually diminishes in girth to the upper end 2b. About midway the length of said standard a channel is formed on the outer surface thereof, the walls of the standard increasing in width from this channel downwards while the walls within the channel diminish in width from said channel upwards, consequently their tapering formation affords better facilities for the production thereof by moulding. The channel 3 affords means for the ready mounting in position of a tray 4 for the receipt of any cuttings or liquids which descend from the machine, and this tray may be either loosely mounted upon the standards by its outer ends 4a being curved to fit portions of the channels 3 at both ends. As an additional means of providing against the splashing of the lubricant falling from the motor parts of the lathe, a supplementary tray 5 of the shape shown may be made use of,



in which case the channel parts 5a and 5b span the upper end 2b of the support 2, while a central channel part 5c passes through an opening made through the upper part 2b of the support 2. This formation of the additional tray 5 enables the lubricant that descends from the operating parts to be received by this tray and conducted by it into the main tray 4, which extends from support to support at each end of the lathe bed. (*Accepted May* 27, 1920.)

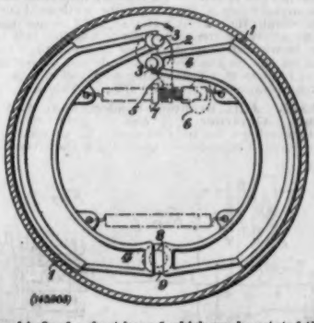
143,122. G. Taylor, Manchester. Metal Punching Tools. (4 *Figs.*) September 18, 1919.—The invention relates to metal punching tools and the means employed for holding such tools in position in the punch ram. The invention consists of a holder for punching tools comprising an adaptor one end of which is turned to fit the punch holder on the end of the ram, whilst the other end is recessed out to receive a bush which, in turn, is formed with a longitudinally-disposed hole from end to end, of such a size as to slidably receive the shank to the punching tool proper and means for retaining the tool in position therein. *a* is the body of the adaptor, which is turned to shape. The



upper end *b* is turned to fit the punch holder on the end of the punch ram. The lower end *c* is bored out to constitute a circular recess *d* of such a diameter as to accommodate snugly a bushing *e*. This bushing, which may be constructed from the same material as the adaptor body, is bored centrally right through to receive the stem of the punching tool *f*. A transverse hole *g* is drilled through the side of the bushing into the central hole when the bushing is in position, which transverse hole registers with a tapped hole A in the side of the lower end *c* of the adaptor body for the reception of a screw *i*, by means of which the tool is held firmly in the bushing and the bushing is simultaneously retained thereby in the recess *d*. (*Accepted May* 27, 1920.)

MOTOR ROAD VEHICLES.

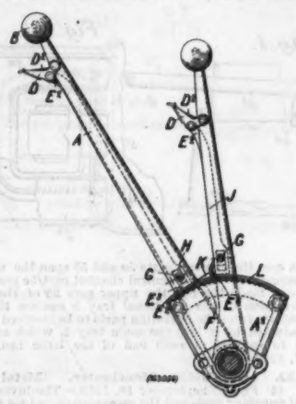
143,005. Riley (Coventry), Limited, Coventry, and H. Rush, Coventry. Expanding Brakes. (2 *Figs.*) April 25, 1919.—The invention relates to internal expanding brakes such as are employed on automobiles, velocipedes and the like, and according to the invention the brake shoes are mounted eccentrically upon a single rotatable hinge pin, and means are provided for rotating the pin whereby the shoes are separated to take up the wear as the pin is turned. 1 is the brake drum, 2 the hinge pin, which is provided at its inner end with two short pins or cranks 3 upon which are mounted the brake shoes 4, whilst on



the outer end is fixed a short lever 5 which can be rotated through a certain angle by a thumb screw 6 passing through a threaded hole in the lever 5 and acting against a fixed stop 7. 8 is a rod having at its inner end an actuating cam 9 adapted to press against the ends of the brake shoes 4, and at its outer end an actuating lever. In the unadjusted position the two cranks 3 are approximately in line with the actuating cam 9, so that by turning the hinge pin 2 by means of the thumb screw 6 the shoes 4 can be moved away from each other to take up the wear. (*Accepted* May 27, 1920.)

143,054. Humber, Limited, Coventry, and L. J. Shorter, Coventry. Control Levers. (5 *Figs.*) May 31, 1919.—The invention relates to control levers as used on motor vehicles, and consists in making the lever of sheet metal of U-section and arranging the catch, or catch-operating rod, in the channel. The brake lever A is of U-section tapering towards the upper end, where it may become circular. This circular part is threaded and receives a knob B. The lower end A^2 is spread and attached to a collar by which the lever is secured or pivoted. To the

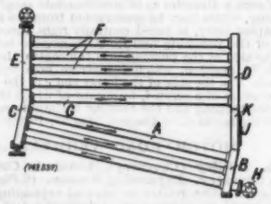
lever A is pivotted a trigger D of bell-crank form, which is of U-shaped metal, and a spring D^2 lies in the channel of the trigger and that of the lever A, so as to hold the trigger in one position. Pivotted to the angle of the trigger D is the catch rod E^2. The catch itself, which is toothed at its lower end where it engages the quadrant F is extended up as shown at E^2, and is pivotted to the trigger. The catch comprises a strip of metal which lies in the channel of the lever A. To guide the lower end of the catch,



a pin G on the lever A passes through a slot E^3 in the catch, and has a square block H pivotted upon it to provide a good bearing surface. Thus the catch is free to slide and to pivot slightly. The quadrant passes through a slot in the lever. In the gear-changing lever J, the same arrangement of catch and trigger is used, but the catch is formed with an ear E^2, which projects laterally and is adapted to engage the stop K on the "gate" quadrant L. (*Accepted May* 27, 1920.)

STEAM ENGINES, PRODUCERS, HOLDERS, &c.

142,537. E. Green and Son, Limited, Wakefield, and G. E. Tansley, Wakefield. Economisers. (2 *Figs.*) February 1, 1919.—The invention consists in dividing the system into upper and lower sets of headers and tubes, the connection between the two sets being by a row or rows of tubes inserted in the lower headers at one end or side, and in the upper headers at the opposite end or side, the connecting row or rows of tubes being common to both the upper and lower systems, the lower sections, those at which the water enters, having the pipes A and also, if required, the headers B, C, positioned at an angle to the horizontal, and the other installation with the headers D, E, vertical, and the tubes F horizontal, the two being connected by the tubes G. The water enters a back collector H and passes into the bottom row of headers B, along the angled tubes A, rising



gradually to the front headers C from which a row or rows of tubes G conveys the water horizontally to the back and to the bottom of the vertical headers D, from which the water is conveyed horizontally along the upper tubes F to the front vertical headers E, and into a top collector. A space is arranged between the tops of back angled headers B and the bottoms of back vertical headers D to allow for the easy inspection and callipering of the angled tubes A, these being the portions of the economiser which contain the coldest water and will require more frequent inspection. When the economiser is working, this space will be closed in with an inspection door J fitted to a framework K resting on the back-angled headers B and supporting the back vertical headers D. This arrangement will also facilitate hand-cleaning operations. (*Accepted May* 19, 1920.)

142,547. J. L. Brunton, London, and W. P. Brunton, London. Governor. (3 *Figs.*) February 4, 1919.—The invention relates to improvements in governors for steam-operated hydraulic systems. According to the invention, a pivoted

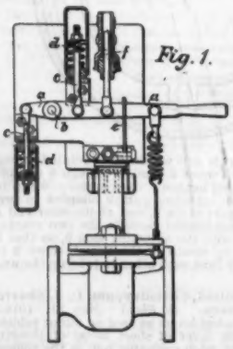


Fig. 1.

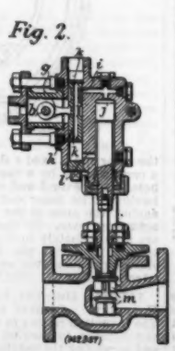


Fig. 2.

arm is turned about its pivot by the pressure in the hydraulic system against the action of a spring and the arm is connected to a valve which controls the admission of steam to a cylinder having a differential piston connected to a valve controlling the supply of steam to the pump of the hydraulic system. *a* is the arm mounted on a shaft *b*. To it are attached two rods *c* which pass through springs *d*. The action of the springs *d* tends to maintain the arm in a central position in which it may be held by a tubular catch *e*. The arm *a* is connected to and actuated by the piston *f* of a cylinder in the hydraulic system. On the shaft *b* is an arm *g* which actuates a piston valve *h* which controls the admission of steam to a port *i* leading to the larger end of a differential piston *j*, and has a longitudinal passage *k* through which steam is supplied to the port *l* leading to the smaller end of the differential piston *j*. The differential piston is connected to double beat valves *m*, which control the supply of steam to the pump of the hydraulic system. When the hydraulic pressure rises, the piston *f* moves the arm *a* against the action of the springs *d*, *d*, thereby also turning the shaft *b* and the arm *g*, which move the piston valve *h* downwards, so that the larger end of the differential piston *j* is opened to pressure and the valves *m* are closed. When the hydraulic pressure falls, the springs *d* turn the arm *a* moving the piston valve *h* upwards so that the larger end of the differential piston *j* is opened to exhaust and the smaller end, being always open to steam, the piston *j* is moved upwards and the steam valves *m* opened. (*Accepted May* 19, 1920.)

142,591. W. L. Rowe, London, G. W. Wright, London, and G. H. Bullick, Wembley. Stuffing-Box. (5 *Figs.*) March 4, 1919.—The invention relates to stuffing-boxes of the kind furnished with self-centring metallic packing. The inner end surface of the gland F is made with a curved tapered recess H, into which there is pressed, by means of a spiral spring K seated in the stuffing-box G, a curved taper packing I of the usual split rings of anti-friction metal. The rings have a central hole to fit the reciprocating piston-rod J, and they are split radially in the usual way. The rings are superposed with the splits at different positions around the rod J. Each ring has on its upper face a key, and in its underface a corresponding recess for interlocking purposes. When fitted together, the superposed rings form a

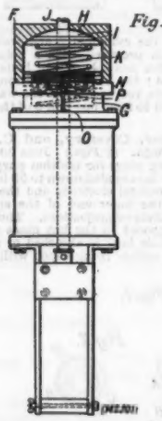


Fig. 1.

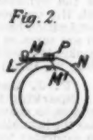
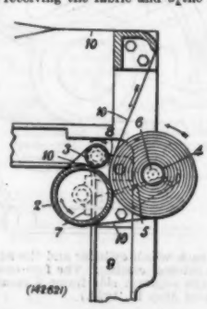


Fig. 2.

curved tapered member I, which is placed in the recess H of the gland F, without the presence of intermediary parts, where it is kept in position by a spring K seated in the hollow of the stuffing-box G. The gland F is screwed on to the stuffing-box and around its outer periphery there are provided a series of recesses into any one of which can engage a pin L fitted on a small locking lever M, pivoted at P to a collar N or, if desired, directly to the stuffing-box. The collar N has a flat for the better reception of the lever M, the flat providing a stop M1 against which the lever can abut when turned into its engaging position. The collar N can slide along the exterior of the stuffing-box and be secured in any endwise position on the box G by means of a set screw P in engagement in a longitudinal slot or groove O on the box G. (*Accepted May* 19, 1920.)

TEXTILE MACHINERY.

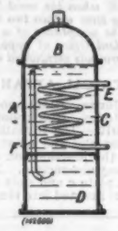
142,621. J. Bentley, Bradford. Take-up Motions for Looms. (2 *Figs.*) March 29, 1919.—The invention relates to take-up motions for looms for weaving and consists of arranging the parts forming these mechanisms and revolving the usual take-up roller in such a direction as to more tightly wind or coil the fabric round the beam for receiving same, which latter is driven by frictional contact from the said take-up roller. 2 represents the take-up roller revolving in the direction of its arrow, which is in the opposite direction to that hitherto proposed in this class of loom, 3 the supplemental roller located as shown, 4 the beam for receiving the fabric and 5, the inclined brackets



or supports carrying the reduced ends 6 of the beam 4, which thereby presses or falls against the revolving take-up roller 2. The take-up and supplemental rollers are mounted by their reduced ends in brackets 7 and 8 respectively. The brackets 5, 7 and 8 are secured to each side frame 9. The fabric 10 passes between the beam 4 and the take-up roller 2, partly round the latter, then between the take-up roller 2 and the supplemental roller 3, over the latter and backwards partly round the take-up roller 2 on to the beam 4. By this arrangement and direction of rotation of the take-up roller the fabric can be more tightly wound round the beam, there being a tendency to press the reduced ends 6 of the beam against the inclined bearing surfaces of the inclined brackets 5 and the coiling fabric on the beam against the revolving take-up roller 2. (*Accepted May* 19, 1920.)

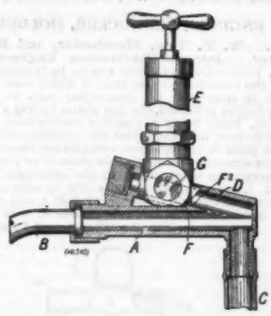
MISCELLANEOUS.

142,669. C. Turnbull, Teignmouth. Boilers for Distilling Water. (1 *Fig.*) May 16, 1919.—According to the invention, in water-distilling apparatus of the type in which steam flows through a coiled tube with vertical axis immersed in the water to be distilled, a settling chamber is provided below the chamber heated by the steam coils, and one or more downcomer tubes open at each end connect the upper part of the heating chamber with the interior part of the settling chamber. A sieve or perforated diaphragm is placed between the two chambers. The rapid circulation effected by these means prevents scale from forming on the hot surfaces and causes the deposition to take



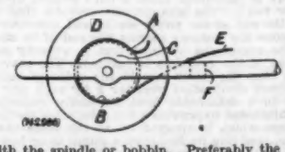
place in a soft condition in the settling chamber, whence it can be easily removed. The ends of the downcomer tubes are bent so that the downcoming water containing the solids in suspension escapes tangentially to the sides of the settling chamber, and a swirling motion is set up which, by centrifugal action, causes the solid particles to be ejected against the walls of the chamber, where they are deposited. A is the shell of the evaporator, B the steam space above the water, C the water space, D a settling chamber below the space C; E are steam coils for heating the water in the space C; F is a tube connecting the upper part of the water space with the settling chamber D, from which any sediment deposited in this chamber can be readily removed. (*Accepted May* 19, 1920.)

141,240. K. Rotherham, Coventry, and W. Johnson, Coventry. Syphon Apparatus. (1 *Fig.*) June 18, 1919.—The invention relates to syphon exhausting apparatus of the type in which the branch communicating with the exhausting pump is arranged above the flow pipe and is inclined so that any liquid in the branch can drain back into the flow pipe. According to the invention, a portion of the flow pipe is formed in the lower part of a single member, the branch to the exhausting pump being formed in the member above and at an angle to the flow pipe so that the dividing wall forms a baffle, the upper side of which is sloping. Any liquid drawn towards the pump during exhausting will settle on this baffle and drain back into the flow pipe. A connection is provided in this branch for the attachment of the pump, also an inspection hole covered by a transparent medium



is formed in the wall of the branch so that it may be seen whether the system is charged with liquid. A casting is bored out lengthwise at A and is provided at each end of the passage so formed with a connection for coupling up to the pipes B and C leading to the upper and lower tanks. This passage A, therefore, forms part of the liquid flow pipe. Above and at an angle to this is a branch D leading to the exhausting pump E, which is vertical and perpendicular to the flow passage A. The upper part F2 of the dividing wall F between the passage A and the branch D is at an angle to the horizontal and consequently any liquid drawn into the branch D will settle on this sloping wall F2 and drain back into the flow passage, or outlet C. In one wall of the branch A is an aperture G, to which a glass face is fitted by means of a screwed ring packed with washers. Through this the inside of the branch D can be seen. (*Sealed.*)

142,986. Thomas and William Smith, Limited, Newcastle-on-Tyne, and S. Pile, Newcastle-on-Tyne. Spindles and Bobbins. (2 *Figs.*) April 8, 1919.—The invention relates to a friction device for spindles and bobbins for use with rope-making machinery. The novel feature consists of a spring, both ends of which are free and not attached to any part of the machine, and so shaped as to embrace a spindle or bobbin, and means are provided for preventing the spring from



turning with the spindle or bobbin. Preferably the spring has an extension adapted to engage with a stationary part of the machine which prevents the spring from turning. The spring is of circular section and engages with a "V" groove in the spindle or bobbin, and may be covered with leather to increase the friction. A is a spring of circular section which engages with a groove B in the spindle C of a bobbin D. One end E of the spring A engages with a fixed arm F which prevents the spring from turning with the bobbin. (*Accepted May* 27, 1920.)